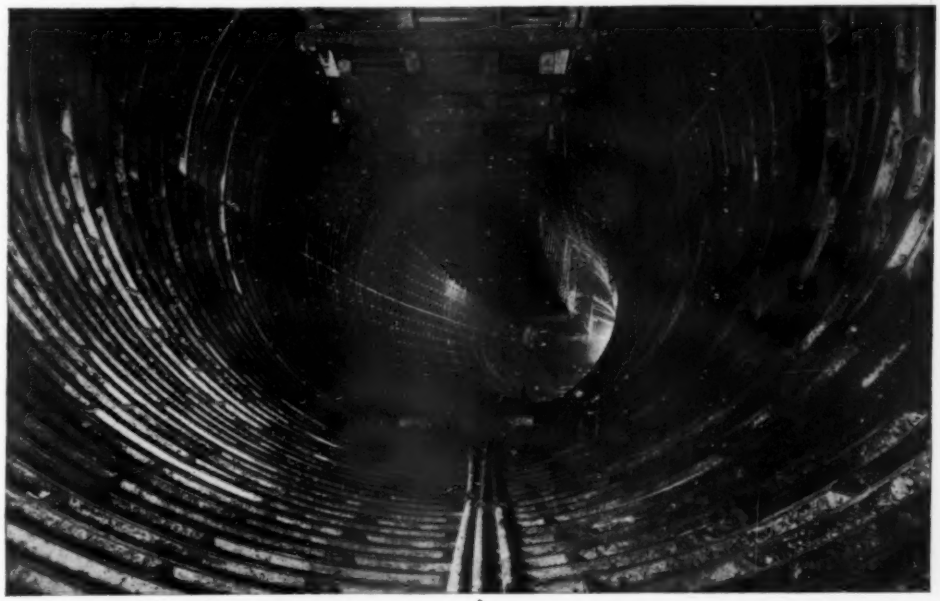
METALLURGIA

THE BRITISH JOURNAL OF METALS.

JUNE, 1934. VOL. X., NO. 56.

Construction of the Mersey Tunnel

The successful completion of the Mersey Tunnel is a noteworthy achievement: the magnitude of the task however, presented many difficulties and in this article brief reference is made to some of the outstanding problems which were successfully solved.



View of lined tunnel taken in February, 1931, looking toward Liverpool from Birkenhead.

INAUGURATED in December, 1925, when Princess Mary Viscountess Lascelles turned compressed air into drills at one of the shafts in Liverpool, the work involved in the construction of the Mersey Tunnel was of great magnitude, and the successful completion of this stupendous and difficult structure is a noteworthy achievement and a credit to British engineering. For many years the problem of improving roadway communication between Liverpool and Birkenhead has been discussed and various schemes and suggestions had been considered. In 1886, for instance, a railway tunnel was successfully completed between the two towns; in 1922, however, the congested state of road transport was realised and the need for adequate relief to meet the increasing use of roads was stressed, and steps were taken to determine the relative advantages and disadvantages of a bridge or a road to supply the growing demand. In that year the Mersey Municipal Co-ordination Committee was organised, under the chairmanship of the late Rt. Hon. Sir Archibald Salvidge, P.C., K.B.E., of Liverpool. This committee took effective measures to promote a scheme, and three eminent engineers were commissioned to report on both a bridge and a tunnel. As a result of this report a tunnel was finally decided upon and plans were prepared, and, as previously stated, the work of driving the tunnel was commenced in 1925.

As will be appreciated, considerable investigatory work was necessary before the plans could be prepared, and the assistance and co-operation of eminent scientists was invaluable, as their expert advice provided a fundamental basis for a proper conception of some of the problems to be encountered, upon the solution of which the successful completion of the tunnel largely depended. It was, for instance, necessary to have reliable information regarding the nature of the ground through which the tunnel had to be driven. The strata of rock under Liverpool and Birkenhead was known, but the outline of the surface of this rock immediately over the proposed line of the tunnel was not accurately known. Certain faults in the rock were known to exist, but definite information regarding them was necessary. Further, it was appreciated that the rock would yield water to a considerable extent, but sufficient information was not then available. It was investigatory work of this character that had to be carried out with extreme care with a view to obtaining reliable data from which to prepare the plans.

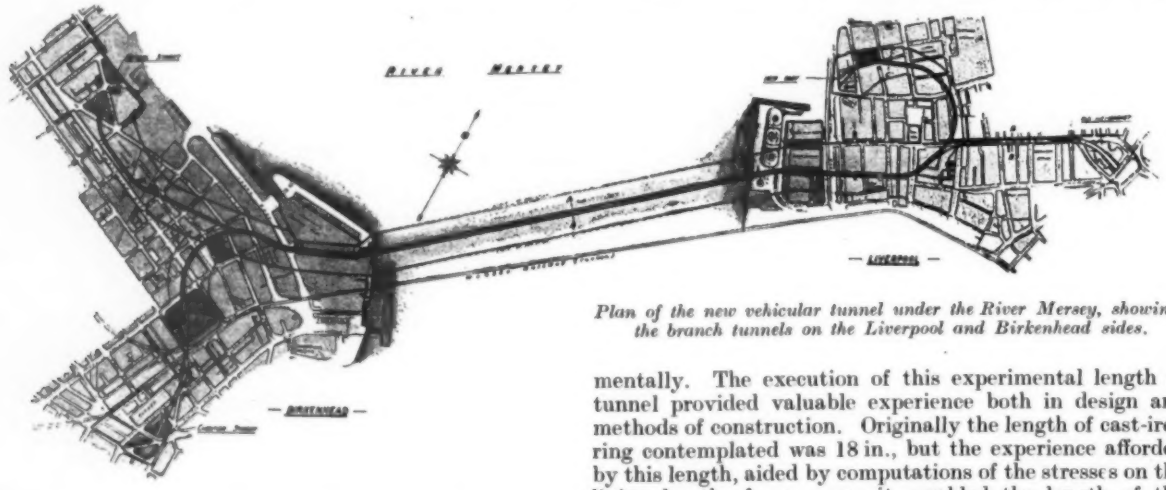
The plans embraced the construction of a tunnel in which the main under-river part would be 44 ft. in diameter, carrying a roadway 36 ft. wide between kerbs, and branch tunnels 26 ft. 6 in. in diameter, carrying roadways 19 ft. wide. The total length of roadway, including open approaches, is 2·87 miles, the length of the 44 ft. tunnel being 2·01 miles, while that of the 26 ft. 6 in. tunnels is 0·61 miles.

The first operation in the construction of the tunnel was to sink shafts about 200 ft. in depth at George's Dock, Liverpool, and at Morpeth Branch Dock in Birkenhead, and to drive from these shafts, which are about a mile apart, small preliminary tunnels or pilot headings along the line of the future main tunnel, in order to explore and prepare the ground preparatory to the execution of the full-sized tunnel. In the complete circular section of tunnel under the river two pilot headings were driven, one near the top and the other near the bottom of the full-sized tunnel. On April 3, 1928, the heading from Liverpool and

Birkenhead met near the middle of the river, and the occasion was marked by a ceremony, in which the late Sir Archibald Salvidge broke through the thin wall of rock left between the two headings. It is of interest to note that the accuracy of the survey work was such that the top headings met under the middle of the river with a divergence of line, level and length of $\frac{5}{8}$ in., $\frac{1}{4}$ in., and 1 in., respectively; while at the bottom these divergences were $\frac{3}{8}$ in., $\frac{1}{2}$ in., and 1 in., respectively.

Following the completion of the pilot headings, work was commenced on enlarging to the full-size tunnels. This consisted of excavating the ground, mainly rock, and erecting the lining for supporting the ground. Cast-iron rings bolted together were generally used, the void between the rock and the back of the lining being filled with a grout of cement and sand pumped in under pressure, this operation being repeated several times for water-tightness. The cast-iron lining was further made water-tight by having all joints lead-caulked and bolts fitted with bitumen grummets, and washers tightened till leaking had stopped.

Where the Tunnel passed above the standing water level, but was still below the rock surface, a lining of rolled steel joists spaced generally at 2 ft. 6 in. centres filled in between with concrete was adopted. Near the entrances at



Plan of the new vehicular tunnel under the River Mersey, showing the branch tunnels on the Liverpool and Birkenhead sides.

Birkenhead, where the Tunnel approached the surface and passed under main throughfares, it was not possible to maintain the semi-circular arch, and here a construction was adopted consisting of a plate girder roof, carried on side retaining walls, thus giving a flat roof section.

From the preliminary or pilot headings the work of enlarging to the full-size tunnels was started in as many places as convenient, each face of one break-up working towards the next break-up until they met. Owing to the immense size of the under-river tunnel, the top half of the full circle had to be excavated, and the lining erected before the bottom half was excavated and the full circle of cast-iron lining completed. As lengths of the lining were completed, work was begun on constructing the reinforced concrete roadway which is built on a line 1 ft. 6 in. below the horizontal diameter in the 44-ft. diameter tunnel, and 7 ft. 3 in. below the corresponding diameter in the 26 ft. 6 in. tunnels.

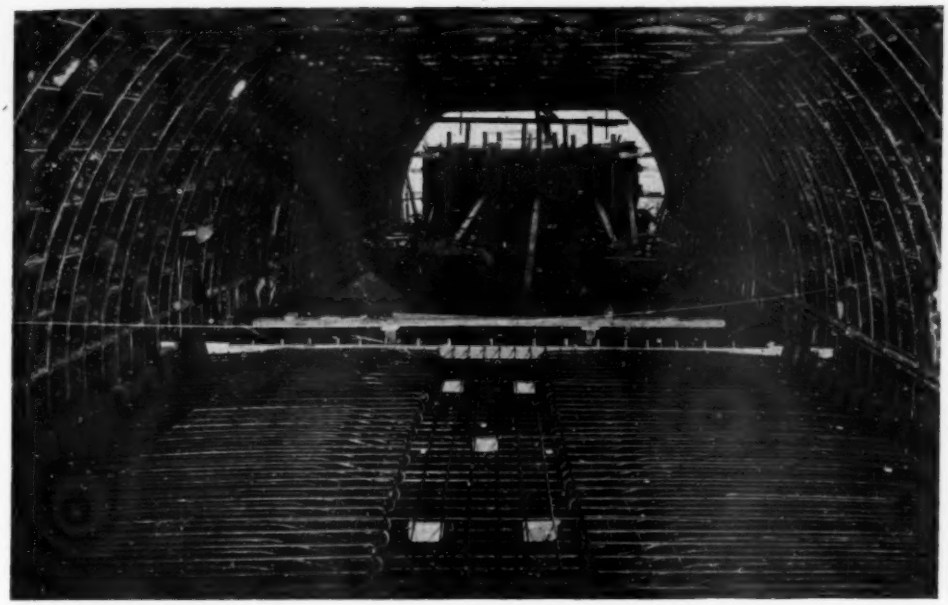
After the main lining and concrete roadway had been completed, the cast-iron segments above roadway level were filled with concrete, followed by the construction of the footpaths, a duct being provided underneath the paving slabs of the footpaths to carry all the electric service cables for the Tunnel. This completed the main structure of the Tunnel and the next operation was to put a smooth finish to its interior. This consists of a cement rendering over the arch down to a height 7 ft. above the footpaths. The rendering is $\frac{3}{4}$ in. thick, and was applied, at a pressure of 30 lb. per sq. in., to the concrete-filled segments by means of a cement gun. The cement rendering is further waterproofed by a coating of bituminous emulsion sprayed on and then finished with a covering of cream-coloured gypsum plaster, which in turn is protected and made water-tight by the application of a transparent polish, also sprayed on. Between the bottom of the plaster work and the footpaths there is a dado of black glass outlined with stainless steel strips. The permanent roadway surface consists of cast-iron setts laid on the reinforced concrete roadway, the lanes for traffic being marked with amber-coloured rubber blocks set in the cast iron. At the entrances the retaining walls of the open approaches are faced with Portland stonework, and traffic plazas are constructed for the proper marshalling of traffic.

The Tunnel Lining.

As already stated, the cross section of the main tunnel under the river was designed as 44 ft. internal diameter, but excavation to a diameter of approximately 46 ft. 3 in. was necessary to receive the cast-iron rings. Each of these rings consisted of 24 segments weighing about 18 cwt., a completed ring weighing about 22 tons. This diameter was greater than that of any similar work previously done, and, to determine the most satisfactory size, a length of the full-sized tunnel was constructed experimentally. The execution of this experimental length of tunnel provided valuable experience both in design and methods of construction. Originally the length of cast-iron ring contemplated was 18 in., but the experience afforded by this length, aided by computations of the stresses on the lining by the forces upon it, enabled the length of the rings in the under-river portion to be increased to 24 in., with a subsequent decrease in cost and an increase in the speed of lining.

The cast-iron segments forming the rings were produced in the foundries of The Stanton Ironworks Co., Ltd., near Nottingham, and over 82,000 tons of these castings were required to form the gigantic cast-iron tube. In all some 111,862 segments were supplied, the majority being 24 in. wide, while a considerable proportion were 30 in. wide, with flanges 13½ in. deep. Curves and inclines in the tunnel were lined by taper rings formed by special segments of varying dimensions. Owing to the unusually large size of these castings, great care and accuracy had to be observed in the moulding and machining operations, so that the tunnel plates would be interchangeable, and would fit accurately into place. They were cast in green sand moulds in fixed core-boxes, particular care being taken to ensure that the metal was of correct composition and temperature, and that the castings remained in the moulds a sufficient length of time to obviate the danger of warping. By the introduction of day and night shifts, two castings were obtained from each moulding-box every 24 hours, and it was thus possible to maintain the high production rate of 1,250 tons of castings per week.

After being removed from the moulds, the castings passed on to large milling machines which faced the flanges at the rate of nearly 100 sq. in. a minute. The accuracy with which the machining operation had to be carried out can be judged from the fact that an error of a hundredth



Reproduction of photograph taken in April, 1931, showing a length of roadway with reinforcing bars in position ready for concreting.

of an inch in one flange only of a segment on one side of a ring would throw the opposite side of the ring as much as half an inch out of the true. Each segment before leaving Stanton was carefully checked by means of templates to ensure that it would fit accurately into its place in the tunnel. As an additional check, however, the segments were periodically assembled into a complete ring.

The Iron Road.

Apart from about 2,000 sq. yds. of the road in the tunnel over two lines of the Mersey Railway, which is rubber paved in order to prevent any damage likely to be caused by vibration set up by heavy traffic, traffic lines and curbs, the whole of the road is paved with Stanton patent "hard stud" cast-iron setts, the number approximating to about half a million. In view of the necessity for a road possessing a very hard wearing surface, considerable experimental work was undertaken at the Stanton works to improve upon the ordinary cast-iron setts, which this Company had made a speciality, and we are indebted to Mr. W. Woodhouse, chief chemist of The Stanton Ironworks Co., Ltd., for the following information regarding these setts.

When this large contract was in view it was realised that something more than an ordinary cast-iron sett would be needed. In consequence, experiments were carried out to produce a sett which should have a hard wearing surface on the face of the studs, whilst leaving the remaining section of the casting capable of resisting shock. The main idea aimed at from a metallurgical point of view was to provide some means to keep the carbon in the combined form on the surface of the stud and thus produce a hard-wearing chill, whilst the carbon in the rest of the casting was in the graphitic form, thus providing a soft iron to withstand shock. After numerous experiments had been made with various chemicals to inhibit the formation of graphitic carbon and the production of combined carbon and chill, a process was evolved which is covered by Patent No. 405772.

This process consists in casting the road sett studs against a metal chill which has previously been treated with sulphur or a sulphur compound. The parts of the mould not to be treated are covered over by a template, which leaves the chill sections exposed. The sulphur compound is sprayed on to the chill surface by means of compressed air. The template is removed and the treated chill is then placed in the casting mould. Sand is rammed into the mould, which is then assembled ready for casting.

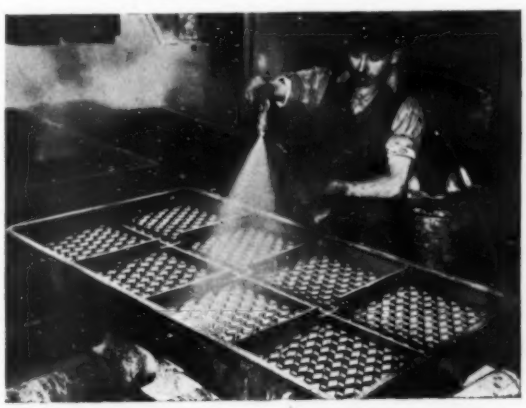
The casting of these cast-iron setts was carried out in a special "Mechanised" Foundry, worked on scientific principles, and in which control of metal, sand, etc., was rigidly carried out. The method of manufacture adopted produces a stud which has a very hard outer surface; the metal in the core of the stud is of a close texture, whilst the remainder of the casting is composed of a softer metal. This stud is very resistant to wear, whereas the more open grain of the remainder of the metal gives strength to the casting and resistance to shock.

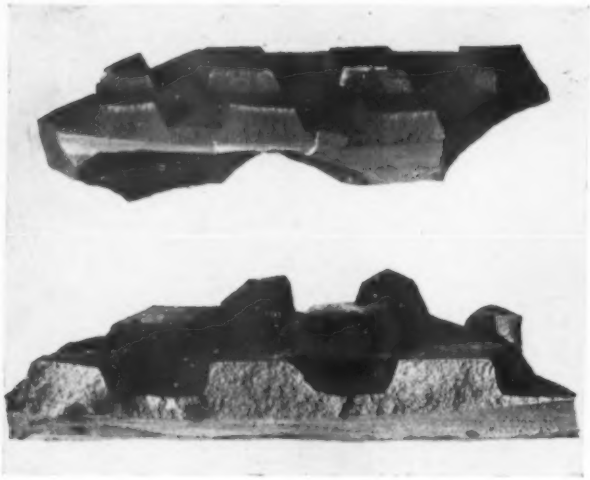
In the case of castings made in the ordinary way, due to the thicker section, the stud portions are naturally more open in structure, and the resistance to wear on them is considerably less than with the "Hard-Stud" type. Some indication of the relative hardness of the "Hard-Stud" road section and an ordinary cast-iron road sett, at various distances from surface, is given in the following figures:

Brinell Hardness $\frac{P}{D_2} = 10$.

	Hard Stud.	Ordinary Road Sett.
Surface	360	210
Inch		
·05 below Surface	340	200
·1 " "	280	200
·2 " "	260	200
·3 " "	220	200
·4 " "	200	193
·5 " "	193	193
·6 " "	185	185

Spraying the chills with sulphur.





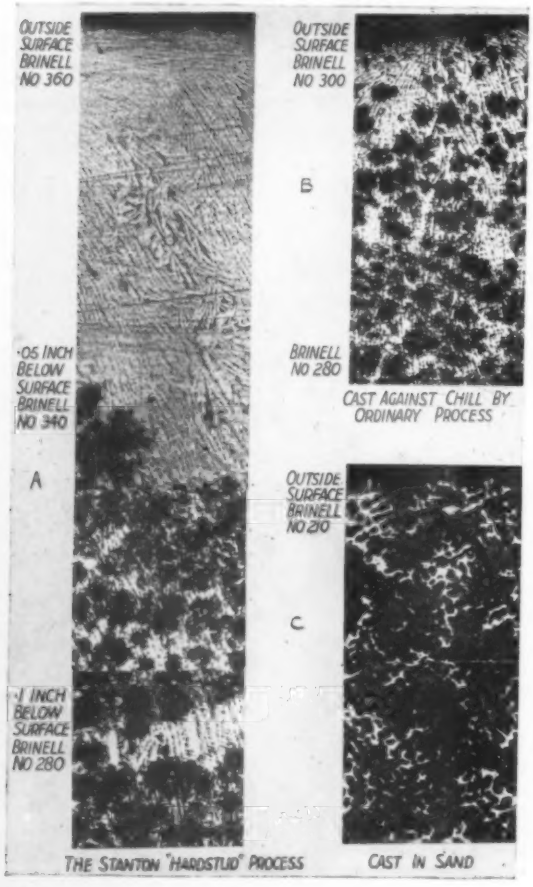
Comparative fractures of a hard-stud road-sett and an ordinary sett.

As is shown in the accompanying illustrations the fracture of the " Hard-Stud " road sett is clearly distinguished from the open structure throughout the depth of the fracture of the untreated road sett ; the hard wearing surface and tough backing of the stud will be noted. The difference in these structures is further exemplified in the comparison of the microstructures shown, in which :—

(*a*) shows a section through a treated " Hard-Stud " which has been cast against a treated chill.

(*b*) shows a section through a stud cast from similar metal to that used for " a " but in this case cast against an untreated chill.

(*c*) shows the same metal cast in a sand mould without any chill.


OUTSIDE SURFACE BRINELL NO 360
·05 INCH BELOW SURFACE BRINELL NO 340
A
·1 INCH BELOW SURFACE BRINELL NO 280
THE STANTON "HARDSTUD" PROCESS
OUTSIDE SURFACE BRINELL NO 300
B
BRINELL NO 280
CAST AGAINST CHILL BY ORDINARY PROCESS
OUTSIDE SURFACE BRINELL NO 210
C
CAST IN SAND

A comparison of these three microstructures gives a good idea of the extent of the chemical action of the sulphur in enhancing the chill effect in the treated stud, as compared with the others.

The structure of the chill portion is austenite-austenitic cementite, verging into austenitic cementite, and in the body of the set the structure is the usual cast-iron structure *i.e*, pearlite graphite, ferrite, phosphide eutectic. This latter is the structure shown in micro C. of a sand-cast stud. B also exhibits the austenite cementite structure but not so marked as in A. The increased hardness in the " Hard-Stud " is brought about by the reaction of the sulphur absorbed into the molten iron surface, preventing some of the carbon from being deposited as graphite and retaining it in the combined form. There is also a probability that some of the sulphur has combined with the iron to form iron sulphide, which has gone into solution in the hard section, thus tending to further increase the hardness and denseness of the stud. As this iron sulphide is in solid solution, it is not identifiable by microscopic methods.

It is of interest to note that many other substances were tried out with varying success, but for ease of applicability sulphur was found to be the best.

Ventilation.

In addition to the main tunnel construction, all the fresh air and exhaust ducts leading from the tunnel to the ventilation buildings had to be built. Apart from the problems associated with construction the question of adequate ventilation was one of the first problems to be solved. In the initial stages this problem was somewhat new as there were no vehicular tunnels of great length in existence, though the ventilation of railway tunnels had previously been carried out. When the principle of a tunnel had been adopted, the Sturtevant Engineering Co., Ltd., were consulted and were instructed to prepare details of alternative systems of ventilation, based on the amount of traffic which it was estimated the tunnel might eventually be called upon to handle. After consultation with Dr. J. S. Haldane, F.R.S., the well-known expert on the toxic effect of carbon monoxide and the other products of the combustion of petrol, it was decided by the engineers to include one of these schemes in the plans embodied in the Parliamentary Bill, and it is this scheme, with slight modifications, which was finally adopted.

Considerable experimental work was necessary before a decision was arrived at and in three ventilation buildings, 14 large Sturtevant fans of varying capacity are installed. the largest being the exhaust fans in the Sidney Street building in Birkenhead, which have each a capacity of 577,000 cubic ft. of air a minute. In the other three ventilating buildings Walker fans are installed. These, which are produced by Walker Bros. (Wigan) Ltd., have a total capacity of 6,750,000 cubic ft. per minute, and are in duplicate. Sixteen fans are installed in these three stations, the smallest having an impeller diameter of 21 ft., and the largest of 28 ft.

To enable the ventilating plant to deal effectively with the widely varying conditions of traffic density and atmosphere that may be anticipated to occur within the tunnel at various times of each day, and during different seasons of the year, the ventilating sets are arranged to give great flexibility of output. The six ventilating stations are electrically operated ; the electrical transformers and electrical switch and control gear, all the fans with their motors and equipment being designed to run under normal service conditions, unattended except for periodical visits of inspection. Control of all stations is effected from a central room. It is of interest to note that all the electrical motors, transformers, switch and control gear, meters, protective relays, and connections inside the stations have been supplied by the Metropolitan-Vickers Electrical Co., Ltd. A special feature of the ventilating sets is that in all the bearings of the motors, reduction gears and fans, thermostats are fitted which, in the event

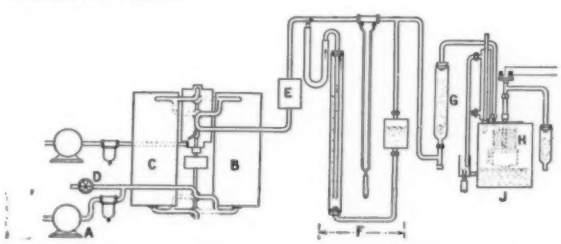
Twelve CO analysers, with their associated indicators, recorders and accessories.

of any single bearing becoming unduly overheated, will cause the electrical control gear to shut down the set concerned.

In order to safeguard the effectiveness of the ventilation in the Tunnel, a comprehensive equipment of extremely sensitive gas-detecting apparatus has been installed by The Cambridge Instrument Company, Ltd. This apparatus measures and records continuously the percentage of carbon-monoxide in the atmosphere, and automatically operates alarm signals if the concentration should rise above a predetermined safe value. The apparatus which measures the carbon-monoxide percentage is known as the Cambridge-Katz Carbon Monoxide Analyser. Its action depends essentially upon the evolution of heat when carbon-monoxide and oxygen combine,

$$2\,CO + O_2 = 2\,CO_2 + 67{,}960 \text{ gram. calories per gram. molecule of CO.}$$

A stream of the air containing carbon-monoxide passes through a mass of catalyst, which promotes the combustion of the carbon-monoxide. The heat generated warms the catalyst mass and the rise of temperature, which is proportional to the concentration of carbon-monoxide in the air, is measured by suitable thermocouples. The potential from these operates indicating or recording instruments and is shown directly as concentration of carbon-monoxide.



Diagrammatic sketch showing essential parts of analyser.

A—Electric blower. B and C—Silica gel dryer. D—Valve.
E—Cleaning canister containing activated carbon. F—Flow regulator.
G—Drying tube. H—Catalyst chamber box. J—Steam bath.

The indicators and recorders are calibrated to give full scale reading with six parts by volume of carbon-monoxide in ten thousand of air. The sensitivity is such that the instruments will readily respond to a change in carbon-monoxide content of one part in one hundred thousand. The twelve CO analysers for the Tunnel with their associated indicators, recorders and accessories, as assembled in the Works during tests, are shown in an accompanying illustration, while the essential parts of the analysers will best be understood by reference to the diagrammatic sketch. A system of alarms ensures due warning of any abnormal increase in the carbon monoxide content in any part of the tunnel. When once actuated the alarms are arranged to remain ringing until stopped by the operator in charge of the local station.

It has only been possible to refer to a few outstanding features in connection with the work involved in the construction of this tunnel, but it will be appreciated that technical ability of a high order has been necessary to give effect to the scheme as planned. There can be no doubt that the new tunnel will not only be of special benefit to Merseyside but of national importance in the rapid distribution of commodities to and from this busy centre.

Effect of Chemical Composition Upon the Wear of Cast Iron.

THE effect of some alloying elements upon the wear resistance of cast iron; when tested under rolling and sliding friction as well as on the spindle saw has been investigated by E. Söhnchen and E. Piwowarsky. The test-pieces were taken from sand cast bars and annealed chill cast bars.

The wear under tolling friction decreases with increasing silicon content. The annealed bars showed a greater wear than the sand cast bars. The difference, however, becomes negligible at higher silicon contents (5% to 6%). Under sliding friction when using water as lubricating medium, the wear increases with increasing silicon content. This is primarily due to the bad effect of silicon upon the corrosion resistance. In the range of 1% to 6% silicon the annealed bars showed a far greater wear than the unannealed bars. When tested on the spindle saw the wear was at a maximum at about 2·5% silicon. The decrease in wear at higher silicon contents must be attributed to the lubricating action of the graphite and the hardness of the silico-ferrite.

The wear under rolling friction of the sand cast bars increases up to about 2% nickel, and then decreases. The decrease is due to the increasing hardness, the refining of the graphite, and the decreasing oxidability of the iron. Of three irons tested the wear under sliding friction slightly increased with two irons, and decreased with the third one. The effect of nickel upon the wear of the annealed bars was negligible. When tested on the spindle saw the wear showed a maximum value at about 2·5% nickel.

Phosphorus reduced the wear under rolling and sliding friction. The optimum effect seems to be obtained already at 0·25%. The same remarks apply to chromium. Under rolling friction the wear slightly decreases up to 0·5% copper. Under sliding friction the decrease in wear with increasing copper content is considerable. This is perhaps due to the lubricating action of rejected copper particles; 0·5% molybdenum reduced the wear under rolling and sliding friction by 25%. Nitrided bars showed only one-third of the wear of untreated bars. (*Archiv fur das Eisenhuttenwesen*, December, 1933.)

A new catalogue has been published which gives technical data relating to the electric resistance alloys manufactured by the Telegraph Construction and Maintenance Co., Ltd., and marketed throughout the world by Wild-Barfield Electric Furnaces Ltd., Elecfurn Works, North Road, London, N. Known as Telcon Metals, these alloys are induction melted, and are available in rod, wire and tapes. Full information regarding their properties is given in this useful booklet, and those interested are advised to obtain a copy.

CORROSION OF METALS BY PHENOLS.

Results of an investigation on the effect of phenol and the cresols on various metals show that the use of copper in stills and containers for phenols at ordinary temperatures should be avoided. It is shown that nickel or the chromium-nickel steels give satisfactory service.

AMONG the organic compounds that are known to corrode steel and other metals are phenol and the cresols. The corrosion observed in stills and fractionating columns handling coal-tar oils is probably due, in part at least, to the action of phenol compounds on the metal. In the design of stills for the refining of phenol and cresols, the metal used in the construction of the condenser coils must resist the chemical action of the vapour and must not cause discoloration of the finished product. The corrosive action of tar acids on metal is also of importance in connection with the operation of the recently developed processes for the purification of petroleum oils by fractional extraction with cresol. Very little information concerning the corrosion of metals by tar acids has been published, but useful data have become available as a result of a series of experiments carried out by Rhodes, Riedel and Hendricks.* The metals used in the experiments included the following : —

Aluminium, commercial pure aluminium sheet.
Copper, electrolytically refined, annealed.
Lead, chemical sheet, 99·8% pure.
Zinc, commercial galvanising spelter.
Nickel, malleable (0·25% Cu, 0·066% Mn, 0·59% Fe, 0·019% S, 0·21% Si, 0·08% C).
Monel metal (29·98% Cu, 66·75% Ni, 1·61% Fe).
Silver, pure electrolytic sheet.
High-carbon steel (1·4% C).
Low-carbon steel (0·2% C).
Brass (64·15% Cu, 35·3% Zn).
High-chromium steel (14·3% Cr, 0·12% C, 0·004% S, 0·006% P, 0·2% Si, 0·52% Mn).
Chromium-nickel steel (17·9% Cr, 7·6% Ni, 0·15% C, 0·006% S, 0·005% P, 0·24% Si, 0·48% Mn).

The phenol and the cresols, with which these metals were tested, were prepared from material purchased as chemically pure and further purified by two distillations, in glass, through an efficient fractionating column. The purified materials were stored in sealed containers until used. As a result of experiments it was found that the rates of corrosion of the various metals by dry tar acids, wet tar acids, at 25° C. were as follows :—

DRY TAR ACIDS.

Metal.	Loss in Weight. Phenol.	*o*-Cresol.	*m*-Cresol.
	Mg. per sq. dm. per 24 hours.		
Aluminium	0·28	0·15	0·05
Copper	0·92	1·7	1·0
Lead	126	66·5	78·5
Zinc	0·13	0·26	0·15
Nickel	0·13	0·05	0·01
Monel metal	0·31	0·08	0·05
Silver	0·03	0·06	0·04
High-carbon steel	0·46	0·04	0·04
Low-carbon steel	0·72	0·26	0·10
Brass	0·13	0·20	—
High-chromium steel	0·19	0·21	0·17
Chromium-nickel steel	0·15	0·16	0·16

WET TAR ACIDS.

Metal.	Loss in Weight. Phenol.	*o*-Cresol.	*m*-Cresol.
	Mg. per sq. dm. per 24 hours.		
Aluminium	0·01	0·02	0·11
Copper	0·23	0·66	0·35
Lead	61·5	38·84	82·4
Zinc	0·17	0·07	0·26
Nickel	0·08	0·03	0·09
Monel metal	0·22	0·07	0·20
Silver	0·12	0·08	0·13
High-carbon steel	0·205	0·19	0·42
Low-carbon steel	0·33	0·38	0·24
Brass	0·10	0·12	0·12
High-chromium steel	0·16	0·19	0·18
Chromium-nickel steel	0·23	0·13	0·09

* *Ind. & Eng. Chem.*, Vol. 26, No. 5, pp. 533-4.

The corrosion by dry vapours of tar acids and of wet vapours of tar acids at the boiling point were found to be as follows :—

DRY VAPOURS OF TAR ACIDS.

Metal.	Loss in Weight. Phenol.	*o*-Cresol.	*m*-Cresol.
	Mg. per sq. dm. per 24 hours.		
Aluminium	—	—	—
Copper	2·1	3·32	18·6
Lead	1155	—	—
Zinc	—	271	—
Nickel	1·0	1·36	1·75
Monel metal	0·52	1·01	8·75
Silver	1·63	4·55	16·5
High-carbon steel	5·5	7·25	18·1
Low-carbon steel	6·0	6·23	16·5
Brass	2·0	2·2	2·3
High-chromium steel	1·03	2·54	3·4
Chromium-nickel steel	0·05	0·99	3·26

WET VAPOURS OF TAR ACIDS.

Metal.	Loss in Weight. Phenol.	*o*-Cresol.	*m*-Cresol.
	Mg. per sq. dm. per 24 hours.		
Aluminium	1·3	1·9	3·18
Copper	5·87	5·65	13·6
Lead	6·73	167	1650
Zinc	14·9	56·2	282
Nickel	0·99	1·65	0·85
Monel metal	5·25	1·52	3·62
Silver	0·91	1·24	3·28
High-carbon steel	47·2	10·9	62·8
Low-carbon steel	37·2	7·2	28·3
Brass	9·3	12·9	14·8
High-chromium steel	0·80	2·15	0·73
Chromium-nickel steel	1·3	1·37	0·74

In their conclusion the authors state that the results indicate that nickel or the chromium-nickel steels of the 18–8 type should be satisfactory for use in handling and condensing the vapours of phenol or the cresols. Lead is rapidly attacked by tar acids, and should not be used in handling these materials. The use of copper in phenol stills and containers for phenols at ordinary temperatures should be avoided, both because the copper itself is attacked to a considerable extent and also because the products of the action of the tar acids on copper cause discoloration of the phenol or cresol.

British Standard Chemical Lead.

First issued in 1928, the B.S. Specification No. 334, for chemical lead has been revised as a result of the experience gained by its adoption which indicated the desirability of a number of amendments. The use of lead to which alloying elements have been added has increased rapidly. The scope of the specification has therefore been extended to provide for two types of lead—Type A and Type B. Type A lead corresponds to the quality of lead covered by the original specification, and Type B provides for lead to which alloying elements have been added.

Additional requirements have also been included specifying the method in which the samples for analysis should be taken. All the tests have been carefully reviewed and a number of details have been modified so as to remove certain ambiguities and to make the methods of carrying out the tests clearer with a view of securing greater uniformity in results. In its revised form the specification should prove exceedingly useful to all chemical engineers and others who are interested in the use and application of lead in industry.

Copies of this British Standard Speicfication No. 334-1934 may be obtained from the Publications Department, British Standards Institution, 28, Victoria Street, London, S.W. 1, price 2/2 post free.

Nickel for Spanish Coinage.

An order has been placed in this country on behalf of the Spanish Mint for 21 tons of Mond nickel, which will be used in the manufacture of 3 million peseta's worth of 25 centimos coins.

METALLURGIA

The British Journal of Metals

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PRINCIPAL CONTENTS IN THIS ISSUE:

	Page
Construction of the Mersey Tunnel .. *The successful completion of the Mersey Tunnel is a noteworthy achievement, and in this article reference is made to a few of the outstanding problems encountered which were successfully solved.*	31–35
Corrosion of Metals by Phenols .. .. *Results of an investigation on the effect of phenols on various metals.*	36
The Mersey Tunnel	38
Non-Ferrous Metals Research Association	39
Improved Working of Soviet Iron and Steel Works. By a Special Correspondent .. .. *Substantial progress in operating the many new plants is emphasised by comparative data.*	40
Transformation of Austentite in High-speed Steel	40
Pulverised Fuel for Metallurgical Work. By a Special Correspondent .. .. *There are circumstances to which the metallurgist must give careful thought when contemplating any departure from heating conditions, as they may exist in his particular furnace, but the use of coal in pulverised form offers many definite advantages and has wide applications. These are discussed in this article.*	41–43
Magnesium-Chromium as a Deoxidizer of Copper. By Charles Vickers .. *An alloy is discussed which is claimed to have considerable merit as a deoxidizer and strengthener of bronze, red brass, yellow brass and other alloys of copper.*	43
Annual Meeting of the Institute of British Foundrymen .. .. *The thirty-first annual conference of this Institute, held in Manchester recently, proved both interesting and instructive.*	44–46
The Classification, Properties, and Utilisation of Non-ferrous Scrap Metals and Alloys. By a Special Correspondent .. .. *The problems associated with the economical utilisation of scrap metals and alloys are discussed with a view to their profitable use. The influence of various alloying elements in remitting the scrap is considered.*	47–48
Association of German Metallurgists ..	49–50
The Iron and Steel Institute .. .. *Many informative papers were presented at the sixty-fifth annual general meeting of this Institute which are briefly summarised in this article.*	51–54
Two New Universal Microscopes .. .. *The previous trend of microscopic design has been in the development of special instruments to meet the requirements of particular fields of research work; efforts in this direction, however, are now being mainly directed to the development of universal microscopes and two recent developments in this direction are described.*	55–56
Recent Developments in Tools and Equipment .. .. *Powerful Lathe for Boiler Drums.*	57–58
Some Recent Inventions .. .. .. *Heat Treatment of Light Alloys.* *Adjusting the Gap between Rolls in Rolling Mills.* *Casting Light Alloy Pistons.* *Aluminium Alloys containing Cerium.* *Welding Rods.*	59–60
Business Notes and News	61–62
Metal Prices	64

Subscription Rates throughout the World - - 24/- per annum, Post free.

Published Monthly by the Proprietors, THE KENNEDY PRESS LIMITED, at 21, Albion Street, Gaythorn, Manchester.

Telegrams: "Kenpred," Manchester. *Telephone: Central 0098.*

METALLURGIA

THE BRITISH JOURNAL OF METALS.

THE MERSEY TUNNEL.

QUICKER and easier methods of transport are developing at a rapid rate and the demand for improvement persists. With these developments road transport is being increasingly employed, and to avoid congestion improvements are being effected on a large scale. The problem of roadway communication is not new, but during recent years it has been intensified and particular attention has been directed to distribution centres. Of these, not the least important is Merseyside—a fact which is appreciated when it is realised that an annual amount of about 12,000,000 tons of cargo is handled at the docks. It is obvious that every facility must be provided to effect the free and rapid movement of this traffic. For many years it has been realised that better facilities were necessary between Liverpool and Birkenhead, and many schemes and suggestions have been put forward with this end in view. In 1922 a committee, known as the Merseyside Municipal Co-ordination Committee, was organised to consider ways and means. This committee appointed three engineers to make a full report on whether a bridge or a tunnel was the better proposition from all points of view. As a result of this report a tunnel scheme was adopted by the committee, which took steps to obtain the necessary Parliamentary powers for its construction.

Plans for a 44-ft. diameter tunnel were placed before Parliament and the Mersey Tunnel Act of 1925 gave the committee powers to proceed with the work, and a statutory body, known as the Mersey Tunnel Joint Committee, was set up to carry out powers conferred by the Act. It was found necessary to modify the original scheme to some extent, and subsequent Acts of 1927 and 1928 provided the necessary Parliamentary sanction for these modifications. In the main, however, the original scheme was adhered to, and as now constructed the tunnel from end to end of the through line traffic is 2·13 miles long, while the total length of roadway through and dock lines together is 2·87 miles. The under-river portion of the tunnel has an internal diameter of 44 ft., and the roadway, between kerbs, is 36 ft. wide, while the width of the branches is 19 ft.

The construction of this tunnel has been a difficult task as numerous problems were encountered which demanded the highest technical skill and ability to overcome. Before work could begin it was necessary to determine the nature of the ground through which the tunnel had to pass. It was known that the strata under Liverpool and Birkenhead was a red Triassic sandstone, which was particularly suited to the work involved, but the outline of the rock surface in relation to the proposed line of the tunnel was not accurately known. It was known that faults existed in the rock, but to what extent was not known, particularly under the river. That considerable influx of water into the workings would take place was appreciated, but the available information gave little or no indication of the behaviour of the underground water. It was, however, known that a glacial channel existed in the rock surface under the water under which the tunnel was required to pass. The initial work, therefore, consisted in exploring and preparing the rock through which the tunnel could ultimately be driven. Subsequently, pilot headings were constructed, which provided a continuous line of communication from one side of the river to the other; it was thus possible to construct the full-sized tunnel at several points along the line.

To take care of water entering the workings drainage headings were driven. These were 7 ft. in diameter, and since it was found that the flows of water amounted to about 2,780 gals. per min. arrangements were made so that the water could be pumped away continuously until the final sealing of the tunnel. During the construction of that part of the tunnel beneath the glacial channel previously mentioned, it was found that the minimum cover of rock was only 3 ft. 6 in., and that the rock at this point was of a poor and broken character; extreme care, therefore, was necessary in driving and lining this part of the tunnel. Despite these and other difficulties, the average rate of excavation during the period of tunnel driving was over 1 ton of rock every 2 mins. from June, 1926, to August, 1931.

Apart from the many problems encountered in driving the tunnel, special problems were presented in cementation, grouting, and waterproofing, while the question of ample ventilation was not less important. It is well known, for instance, that the exhaust fumes from petrol and oil-driven vehicles contaminate the atmosphere, and in a tunnel designed for four lines of traffic adequate ventilation was of primary importance, and it was recognised that means must be provided for ascertaining the percentage of poisonous gases in the air of the tunnel with the object of controlling its purity by suitable ventilation. This problem involved a very careful study of systems adopted in other vehicular tunnels and was solved by means of six ventilating plants, three on each side of the river. Each plant consists of a number of large-sized fans, housed in a building on the surface and connected with the tunnel by means of vertical shafts and horizontal underground air ducts. The total capacity of the ventilating fans is 10,000,000 cub. ft. per min., and the ventilation adopted is known as the upward semi-transverse system.

As completed the tunnel gives very little indication of the work involved, or of the amount of material used in its construction. Designed as a 44-ft. tunnel, a diameter of approximately 46 ft. 3 in. was driven and lined with segmental rings of cast iron, each ring being built from 24 segments weighing about 18 cwt. each. In the branch tunnels and the junctions between them and the main tunnel the shape and size of the lining segments vary somewhat and in many instances their assembly at the works was essential to obtain that degree of accuracy necessary before the rings were assembled in the tunnel. In all, some 82,000 tons of these segments were necessary to complete the lining, and the space between the excavation and the outside of the segments was filled in and grouted, and the joints between the rings subsequently caulked with lead wire to ensure thorough watertightness. In addition to the lining a large tonnage of cast iron is used in the roadway, which is claimed to be the largest stretch of cast-iron roadway in existence. In connection with the lining and roadway, some interesting metallurgical features arise to which reference is made elsewhere in this issue. The construction of this tunnel, however, is undoubtedly a noteworthy achievement of British engineering, and those who have been responsible for the work must be gratified at its successful completion.

NON-FERROUS METALS RESEARCH.

THE fourteenth annual report of the British Non-Ferrous Metals Research Association, presented to the general meeting in London, recently, indicates the steadily increasing interest taken by members in the work of the association. During the year 1933 some 410 major technical inquiries were received from member firms in comparison with 276 similar inquiries during 1932 and 219 during 1931. This is important in view of a substantial offer of increased Government support, recently made on behalf of the Department of Scientific and Industrial Research, provided industrial contributions from member firms are correspondingly increased. The character and quality of the work done and in progress is a sufficient quarantee of the utility of this association and the spending of a nominal amount of £22,000 will well save industrialists many times that amount. Unfortunately, it is not yet realised by industrialists that collective research is the finest investment, because it is largely through collective research that the luxuries of to-day become the necessities of to-morrow, making for gradual advancement in the standard of life of the community. It is evident from the report that the Council think the time opportune for a forward movement by the Association, especially with the assurance that an extension of activity will secure a substantial backing from the Government for at least several years to come. The Council are giving careful consideration to the way in which the opportunity can be used to the best advantage, but its difficulty in coming to a decision would be simplified if non-ferrous firms appreciated their obligation in this question of research.

Reviewing the research work carried out, the report states that considerable progress has been made with the study of the effect of impurities on the mechanical and rolling properties of various non-ferrous metals, and the influence of varying amounts of different impurities on the quality of the finished product. A thorough survey of the possibility of eliminating bismuth from copper in fire-refining will be put in hand during the year. The latest optical methods are being employed for determining the amount of impurities, especially those of sodium and tellurium, in lead and its alloys. The results of methods for estimating minor constituents in zinc, tin and copper have been published, and similar work on aluminium is in its final stage.

In view of the increased use of electro-plated goods in the home and in industry, it is interesting to note that as a result of researches on the electro-plating of nickel, copper and chromium, methods have been developed for preventing the porosity which leads in time to the formation of unsightly spots of corrosion, and for obtaining a better adhesion of the deposits. Work on the electro-deposition of tin has shown that sound tin deposits of any desired thickness can be produced; coatings as thin as 1/2,000 of an inch in thickness on steel have been found to be substantially free from pores. A process has been developed for the elimination of porosity in hot dipped tin coatings on steel. Further work is being directed towards improvement in the quality of tin-plate, and an experimental tinning machine has been installed for this purpose.

An improvement in the soundness of aluminium castings has been made possible by the development of a simple method for the removal of dissolved gases. Investigations have shown that the method is practical and the results show it to be effective. Large tests on melts up to 600 lb. have been made, at a total cost estimated to be less than one-tenth of a penny per lb. of metal, with very satisfactory results.

The new lead alloys originally developed for the prevention of cracking in cable sheathing are being applied to domestic water pipes. It is noteworthy that licenses have been granted by the Association for working its patents for the manufacture of cable sheathing in France, Spain, Italy, and also in the United States in collaboration with the member firm holding the master license for the United States. A licence for the manufacture of pipe and sheet has also been granted in Australia, and negotiations for similar licences in some foreign countries are in progress. Apart from the actual work involved in securing new licenses, supervision of existing arrangements both as regards the licences and the use of the Standardisation Trade Mark on water pipe of British manufacture require constant attention.

Experimental work in connection with soil corrosion tests of water pipes, of lead, copper, and Ternary Alloy Nos. 1 and 2, and roofing sheet tests on lead and the two Ternary Alloys, is continuing, but it will naturally be some time before useful results are obtained. The examination of tellurium lead in conjunction with the research on Frost Bursting of Water pipes has also been continued and apart from the value of this work in providing members with independent opinion on the properties of the alloy it has revealed some interesting points concerning the general properties of lead alloys. Sheets of tellurium lead have been included in the tests of roofing sheets and as opportunity offers, by the removal of earlier samples, tellurium lead pipes are being added to the series of soil corrosion tests.

The increased use of bright metals has led the Association to study tarnish on the polished surfaces of various materials

In this investigation the effects of tarnish on the polished surfaces of the various materials tested have been expressed on a quantitative basis using a special method of measuring reflection properties. This method has been developed with the kind co-operation of the Research Laboratories of the General Electric Co., Ltd., and the apparatus is being kept available for possible future work. The scope of the research also covered a determination of the effects of various types of methods of removing tarnish, together with the effects of cleaning treatment upon the subsequent rate of tarnishing.

In the past, many of the most important investigations carried out on behalf of the Association have been conducted in the laboratories of the National Physical Laboratory, the Research Department at Woolwich, or at Universities. The Council appreciate however, that a better-balanced team of research workers could be secured by concentrating much of this extra-mural work in the Association's own laboratories in London, and this is being done. Where special equipment and experience is demanded the Association will still turn for help to the various laboratories available.

Iron and Steel Institute.

The Autumn Meeting of the Iron and Steel Institute for 1934 will be held in Belgium and Luxemburg, by the kind invitation of the iron and steel manufacturers of those countries. The date for the opening of the meeting has been fixed for Monday, September 10. The sessions for the reading and discussion of papers will take place in Brussels on the mornings of Monday and Tuesday, September 10 and 11. Visits will also be paid to the industrial centres of Belgium, including on Wednesday, September 12, an excursion to Liege. On the evening of Wednesday, September 12, the party will travel to Luxemburg, where arrangements are being made to visit the chief iron and steel manufacturing plants of that country. A full programme of visits to places of general interest and of several functions in Belgium and Luxemburg is being prepared.

Negotiations are in progress with the railway authorities concerned for the members resident in the United Kingdom to leave London by special train on Saturday, September 8, arriving in Brussels the same evening. The complete programme of the meeting and visits and excursions will be announced at a later date; but as it is desirable to ascertain as soon as possible the approximate number of persons likely to take part in the meeting, members are advised to communicate with the Secretary of the Institute, Mr. K. Headlam Morley, at an early date.

IMPROVED WORKING OF SOVIET IRON AND STEEL WORKS.

BY A SPECIAL CORRESPONDENT.

Despite the difficulties associated with the rapid development of the iron and steel industry in Russia the author of this article is able to report substantial progress in operating the many new plants.

A MARKED improvement is recorded during the first four months of the present year in the operation of blast-furnaces and steel smelting shops in the Soviet. There is evidence of this in the increased figures of production. The output of cast iron in the first four months of the year, for instance, was 3,103,000 tons, which, in comparison with the corresponding period of the preceding year, when it was 1,960,000 tons, represents an increase of 143,000 tons, or 58% in the production of cast iron. It is noteworthy that the furnaces put into operation after April, 1933, had an output of 579,600 tons, while those which started working before April, 1933, had an increased output of 563,500 tons.

This progress has been the result of the improved technique and increased concentration on the production of the blast-furnaces, an indication of which is clearly seen in the accompanying table relating to the utilisation of the useful volume of blast-furnaces. The coefficient of the utilisation of the volume of blast-furnaces shows the volume of furnace required for the production of one ton of cast iron; the decline in the volume being indicative of the advances made.

THE COEFFICIENT OF UTILISATION OF THE VOLUME OF BLAST-FURNACES IN THE DIFFERENT WORKS OF THE U.S.S.R.
(Square Metres per Ton.)

Works.	1928-29	1929-30	1931	1932	Second Quarter. 1933	April. 1934
Magnitogorsk	—	—	—	1·77	1·91	1·07
Azovstal	—	—	—	—	—	1·11
Makeevski	1·65	1·66	1·70	1·48	1·42	1·13
Stalin	1·60	1·36	1·58	1·46	1·30	1·17
Saporozhstal	—	—	—	—	—	1·21
Petrovski	1·69	1·51	1·67	1·48	1·55	1·22
Voroshilov	1·98	1·73	1·79	1·58	1·82	1·23
Frunze	2·00	1·94	1·55	1·93	2·31	1·52
Kosogorski	2·13	2·39	1·93	2·21	2·17	1·73
Kerchenski	2·34	2·04	2·41	2·02	2·22	1·84

The plants that have most improved their technique of production are the Magnitogorsk and Azovstal. These are considered to be two of the most up-to-date works in the Soviet Union, having some of the very latest equipment. In the fourth blast-furnace at Magnitogorsk, the coefficient of utilisation of the useful volume is lower than unity. This is recognised as a very marked improvement.

Though the foregoing figures show commendable advances made in the fuller utilisation of the blast-furnaces, they nevertheless reveal great disparity between the operation of different plants, working under similar conditions. Apparently the plants have not yet solved an important problem—that of operating the blast-furnaces regularly, without stoppages. The progress already made, however, has not only resulted in the increased production of pig iron, but in a considerable economy in the consumption of raw materials, fuel and electric energy. In nearly all the works last April, and also during the first quarter, the consumption of coke per ton of cast iron had declined. In the plants in the South, forming the Azovstal combination, the consumption of coke per ton of iron during the first quarter of 1934 declined by 5%, as compared with the fourth quarter of 1933.

Definite progress has also been made by the steel-making plants. During the four months under review the output of steel was 2,899,000 tons, or 50% greater than in the corresponding period of the previous year. The greatest proportion of this increased output is due to the bigger production of steel per square metre of hearth. This is illustrated by the following table:—

AVERAGE DAILY PRODUCTION OF STEEL IN TONS PER SQUARE METRE.

Works.	1931.	1932.	April, 1934.
Hammer and Sickle (Moscow)	3·39	3·33	4·51
Comintern	2·88	3·58	4·43
Lisvenski	2·41	2·46	4·37
Makeevski	3·12	3·70	4·27
Saldinski	2·66	3·43	3·96
Petrovski	3·21	2·92	3·76
Stalin	2·84	2·97	3·74
Frunze	2·70	2·74	3·67
Taganrog	3·46	2·87	3·17
Voroshilov	2·38	2·29	2·96

The best figures are shown by the Hammer and Sickle Works in Moscow, which were the most successful in organising uninterrupted work in the open-hearth furnaces. In the Lisvenski Works, where the production per square metre of hearth was 4·37 tons of steel, stoppages on account of interrupted heat supply was 1·6 of working time. In the Tanganrog Works, where the production was 3·17 tons of steel, stoppages amounted to 10·9% of working time.

In the open-hearth furnaces too, considerable economies were effected in the consumption of raw material and fuel. Thus, in the "Stal" combine, during the first quarter of 1934, the consumption of pig iron and scrap per ton of steel was 0·792 ton, as against 0·819 ton in 1933. This represents a saving of 3·3%. The consumption of fuel in the first quarter of the present year was 0·306 ton, as against 0·336 in 1933. During the four months under review, the work of Soviet metallurgy shows the beginnings of a definite break in its former backwardness and a further mastery of the new units of production. The competition for the most efficient iron and steel plant, organised in the Union last March, is partially reflected in the fewer stoppages and the better working of the plants generally.

Transformation of Austenite in High-speed Steel.

BY magnetic measurements made on a high-speed steel containing about 0·75% carbon, 17% tungsten, 4% chromium, and 1% vanadium, S. Steinberg and V. Süsin have studied the stability of austenite when quenched from various temperatures and the resulting transformation structure. The martensite point falls with increasing quenching temperature. When quenched from 900° C. to 500° C. in a lead bath, and on further slow cooling to room temperature, the austenite transformation begins at about 500° C., and at 150° C. when quenched from 1,300° C. In the temperature range from 600° C to 400° C., and at about 200° C., the austenite is extremely stable. At temperatures above 600° C. the transformation velocity increases with increasing temperature, and shows a maximum value at about 750° C. (first transformation stage); another maximum value was found at 300° C. (second stage). In the first stage the austenite completely decomposes into troostite, carbides being first rejected and then ferrite along with carbides. At the same time, the temperature of the martensite formation rises. In the second stage only part of the austenite decomposes with the formation of martensite-like needles. At the same time the temperature of martensite formation falls and the content of residual austenite at room temperature increases. The transformation of austenite into tetragonal martensite, the completeness of which is dependent upon the cooling rate, forms the third stage. The beginning of this transformation is greatly dependent upon the quenching temperature and the degree of decomposition attained in the former stages. When hardened high-speed steel is heated to 600° C., the residual austenite only decomposes into martensite during cooling below 200° C. (*Archiv fur das Eisenhuttenwesen*, March, 1934.)

Pulverised Fuel for Metallurgical Work

By a Special Correspondent.

There are many circumstances to which the metallurgist must give careful thought when contemplating any departure from heating conditions, as they may exist on his particular furnace, but the use of coal in pulverised form offers many definite advantages and has wide applications. These are discussed in this article.

THE use of pulverised fuel for metallurgical heating offers many important advantages not obtainable with any other form of firing. Briefly these are saving of labour and fuel, reduction of metal losses through oxidation, increased furnace output, more accurate control of temperature, greater degree of heat penetration and elimination of raw coal transport to furnaces. These advantages have been confirmed in practice in America, in Germany and in this country in a great number of instances. The economies which can be affected, indeed, with this form of firing in metallurgical operations are far more evident and actual than in its use for steam raising.

In the early days of the application of pulverised fuel to metallurgical work, the central system of firing was employed, that is the prepared fuel was fed to several furnaces from one main bin. This method has, however, long been discarded and unit firing, that is, each furnace equipped with its own grinding and feeding unit has taken its place. Moreover, every item of pulverised fuel equipment, mill, feeder, and burner, has been so greatly improved that far higher efficiencies are obtainable and the reliability factor is also considerably higher.

This aspect of the matter cannot be emphasised too strongly for the stigma of failure associated with early plants still remains in the application of this form of firing to metallurgical furnaces. That this reputation has now been reversed is proved by the great increase which is being made in the conversion of this type of furnace from hand and oil firing to that of pulverised fuel firing.

From the point of view of capital expenditure, many reductions have been effected in almost every item of equipment, and this has been accompanied by an improvement in efficiency and more economic operation. Pulverised fuel firing has, indeed, become a science, each part of the equipment contributing its quota to the whole process of economic and efficient combustion.

One of the charges made against this form of firing for metallurgical purposes is that the intense flame causes heavy erosion of the refractories. If such a condition does obtain it can be due only to the lack of control of the flame length, for if proper consideration is given to the design and positioning of the burner and correct air quantities and pressures are determined as will ensure a low tip velocity of the coal cloud on admission to the furnace no such disaster can occur.

Pulverised coal is used almost universally for the firing of copper smelting and refining furnaces, an increasing number of annealing furnaces are resorting to this form of firing; in puddling and bushelling furnaces, experience has proved that the wide variations in flame conditions necessary—from highly reducing to intensely oxidising—can be satisfactorily met; the conditions under which billet reheating furnaces are required to work are being closely studied and the problems associated therewith are approaching solution, while the application of this form of firing to the production of cast iron has shown that high strength low-carbon irons can be obtained by the use of the rotary pulverised fuel furnace.

Photograph by courtesy of The Buell Combustion Co., Ltd.
Annealing furnace operating on pulverised fuel.

Cast Iron. The latter development is probably one of the most important in metallurgical practice, in view of the fact that it enables those special conditions to be secured which are essential in the manufacture of this class of iron. These conditions are brought about by the extremely high temperature obtainable with pulverised fuel, and the rotary motion of the furnace, resulting in the melting process being very short. Thus the charge comes in contact with the heating gases for a comparatively short time and oxidation losses can be almost wholly avoided either by using no excess air for combustion or by keeping the flame slightly reducing. The liquefying of the metal and its protective covering with slag excludes it from any further action from the furnace atmosphere, the outer coating of oxide on the metal remaining in the slag. Heat is transmitted to the metal from above through the slag, and from beneath through the heater furnace lining.

In furnaces of this type, irons can be produced to any predetermined analysis as it is possible to maintain the metal in the molten condition in the furnace while analytical tests are carried out, thus ensuring that the metal in the castings will be of the desired composition. Attention has recently been directed to the production of what is termed "short anneal" malleable cast iron. In the manufacture of this, the original iron sometimes contains as little as 1·5% carbon, and only a few hours' treatment is required to produce an extremely strong and ductile iron. The ordinary cupola furnace is quite unsuited for this work, but the desired results have been obtained by means of the rotary pulverised fuel furnace.

It will be interesting to quote figures appertaining to the cost of production by this system.

COST OF CHARGE AND TOTAL COST.

	Shillings.
1,452 lb. grey iron turnings (30s. per ton)	19·80
660 lb. steel turnings (30s. per ton)	9·00
66 lb. of 40% ferro-silicon (£12 per ton)	7·20
17·6 lb. of 80% ferro-manganese (£12 12s. per ton)	2·00
77 lb. of petroleum coke, or old electrodes, or retort carbon (£5 per ton)	3·50
Melting costs (average of 7·9s. and 11s. per ton)	9·50
	51·00

Buell system of pulverised fuel firing will also be of interest to iron and steel manufacturers desirous of reducing costs and increasing output :—

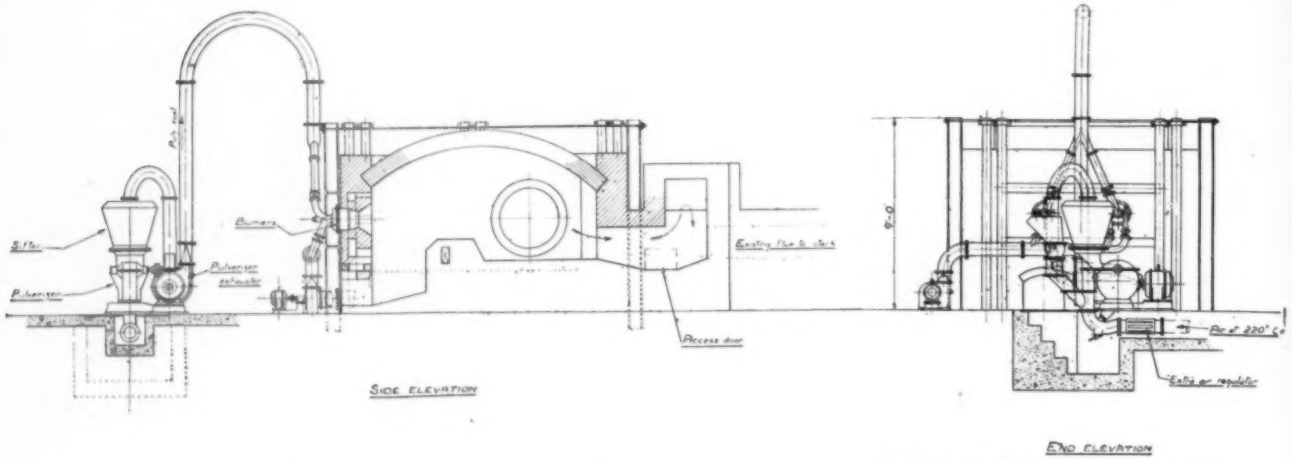
RESULTS FROM FOUR SIX-TON WHITE-HEART ANNEALING FURNACES.

Hand-firing.

Working period, five days per week of 24 hours per day.

Present throughput per furnace, 6 tons ..... = 24 tons per four furnaces.

Present weekly coal consumption, based on 28 cwt. of coal per ton of metal annealed ..... = 24 × 28 × 1/20 = 33·5 tons per week.



Courtesy of the Buell Combustion Co., Ltd.

General arrangement of a 15-ton reheating furnace equipped for the use of pulverised fuel

Malleable Iron.—In the smelting of malleable iron the chief economies are to be found in fuel saving and the time required from charging the furnace to the time of tapping.

The figures from one works on a 20-ton furnace were reported as follows : 15 to 18 minutes per ton of charge, melting time ; fuel ratio, 2·95 tons of metal per ton of coal, on the first heat. On the second heat, melting time was reduced to 12 to 15 minutes per ton of charge, and fuel ratio changed to 3·22 to 3·28 tons of metal per ton of coal burned. On a larger 30-ton furnace the fuel ratio was from 3·57 to 4 tons of metal per ton of coal. Under hand-firing conditions, these furnaces produced the same tonnage of metal per ton of coal.

The time element for melting is also a variable feature under hand-firing conditions. The slightest variation in quality of coal may set back the tapping time and disorganise the day's programme of work, thus increasing

Coal costs at 26s. per ton (average cost), therefore present cost on fuel basis alone = 33.5 × 26 × 1/20 ..... = £43 11s. per week.

Taking 45 weeks per annum, fuel costs on four furnaces = £43 11s. × 45 ..... = £1,959 15s.

Pulverised-fuel Firing.

Working period, five days per week of 24 hours per day.

Throughput per furnace = 6 tons ..... = 24 tons per four furnaces.

Weekly coal consumption of 12 cwt. per ton of metal annealed = 12 × 24 × 1/20 ..... = 14 tons 8 cwt.

Coal costs : 20s. per ton delivered at furnace. Weekly coal cost = 288 × 1/20 ..... = £14 8s.

Taking 45 weeks per annum. Fuel costs on four furnaces ..... = £648

Showing gross saving per annum of £1,959 15s..... = £648

= £1,311 15s.

The nett saving is as follows, taking cost of electricity at 0·9d. per unit. Cost of electricity energy :—

12 k.w. hours × 24 × 5 × 45 × 0·9/240 ..... = £202 10s. 0d.

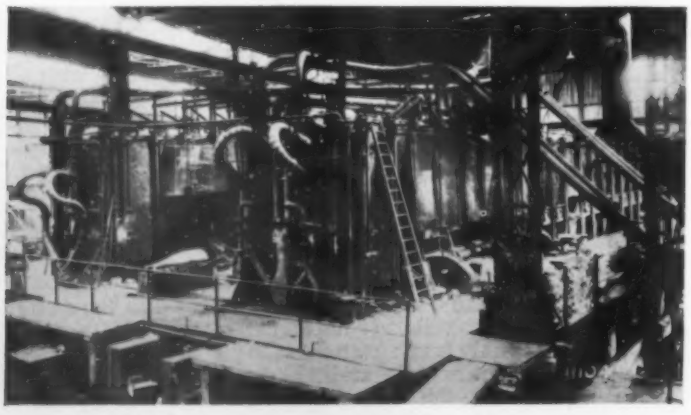
Maintenance at 4d. per ton ground to meet all requirements = 648 × 4 × 1/240 ..... = £10 18s. 0d.

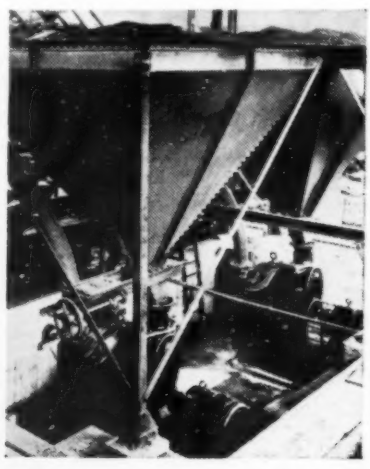
Interest on capital and depreciation of plant ..... = £99 0s. 0d.

£312 8s. 0d.

Nett saving per annum on four furnaces = £1,311 15s. = £312 8s. = £999 7s. 0d.

From photographs by courtesy of Alfred Herbert Ltd.





Reheating furnaces fired with pulverised fuel showing the connections to the burners and on the right the pulverising plant.

production costs and involving overtime pay to moulders. Under pulverised coal firing, the charging, firing and tapping of a furnace can be definitely regulated and scheduled times adhered to.

The following figures, based on the operation of four 6-ton white-heart annealing furnaces, and fired with the

Reheating Furnaces.—In reheating furnaces the use of pulverised fuel has resulted in similar economics and improvements. An illustration is presented of a 15-ton forge reheating furnace fired on the unit system. This furnace under hand-firing consumed coal at the rate of 3·5 cwts. per hour, at 20s. per ton, and with a calorific

value of 13,500 BTU's per lb. When this furnace was converted to pulverised fuel-firing the fuel consumption was 2·1 cwts. per hour, costing 10s. 6d. per ton, and having a calorific value of 12,000 BTU's per lb.

Boiler-plate Furnaces.—The regular heat provided by pulverised fuel-firing makes it particularly well adapted to boiler-plate furnace work. A point also favourable to this class of work is that only a minimum of air is necessary, and thus scaling of the plates is avoided. Furnaces of this type which had been fired by hand after conversion to pulverised fuel-firing were able to burn coal of a lower grade and price while the output was very considerably increased. At the same time the plates are uniformly heated and there is an entire absence of scale.

Non-ferrous Work.—Very striking economies in non-ferrous operations are evidenced by the present day general practice of firing open hearth reverberatory copper smelting furnaces with pulverised coal. The furnaces at one works for instance, after conversion from hand firing, to pulverised coal firing, gave approximately a double output at half the fuel consumption; the figures being, for hand firing, 250 tons of copper per 24 hs., and 3·8 tons of copper per ton of coal; and for pulverised coal firing 475 tons of copper per 24 hrs., and 7 tons of copper per ton of coal.

The application of pulverised fuel to metallurgical furnaces involves altogether different conditions to those obtaining in steam raising. The combustion area is much more restricted and a greater degree of uniformity and fineness of fuel is demanded. The intermixing of air and fuel prior to combustion must also be highly efficient. The design of burners for this purpose have undergone considerable modifications in order that the flame requirements should be perfectly fulfilled. The Buell dispersive burner is one example of a burner by which complete combustion can be obtained within a comparatively short distance of the burner orifice, and the use of such a burner involves very little alteration to the existing furnace. The heavy expenditure hitherto incurred in the reconstruction of combustion chambers and general furnace alterations is therefore no longer necessary. Thus from every point of view, the economic as well as the metallurgical, the adoption of pulverised fuel-firing is a very great advance on the old hand-firing method and even on those in which oil is used as a fuel.

Magnesium-Chromium as a Deoxidizer of Copper

By Charles Vickers

An alloy is discussed which has considerable merit for brass foundry service and which the author believes to be the only combination possible as a universal deoxidizer for copper and copper alloys; it can be used to produce high electric conductivity casting in copper, and is useful as a deoxidizer and strengthener in bronze, red brass, yellow brass and other alloys of copper.

AFTER experimenting with nearly every combination of elements for use in non-ferrous alloys, the writer has come to the conclusion that there are exceedingly few elements that can be used alone to give the best results. Most elements have to be coupled and the best combinations are those in which the acid is associated with the alkali. In the case of copper, I have found these give the highest conductivity. The combination I refer to in this short article is a magnesium-chromium copper. Magnesium is not much of a success alone; neither is chromium, but the two together produce excellent results. The combination was used as follows. A shotted chromium copper was in the market, it was sold as a 10% chromium copper, but it is very doubtful if it would show anywhere like 10% chromium on analysis. A 10% magnesium copper was then made, and there is no difficulty about this, as it is easily made. This is a brittle alloy, so can be broken up into small pieces to be mixed with the chromium copper. The two alloys being in granulated form it was necessary to use a phosphorizer for adding them to the molten copper, to deoxidize it; if not so added the granular metals would float and not enter the copper.

The writer tried melting the chromium copper with the magnesium copper, but was not successful in making a good alloy, perhaps if the chromium copper had been made first and then the magnesium an alloy might have been made that, being massive, would dissolve in the copper without floating and oxidizing in the atmosphere. The tests were made on large heats of copper, some 400-lb. each, but preliminary tests were made on heats of 10,000 grms. each as follows:—

EXPERIMENT No. 1.

Electrolytic copper	10,000 grms.
10% chromium copper	50 ,,
10% magnesium copper	50 ,,

The chromium copper and the magnesium copper were added to the molten copper when the latter was thoroughly fluid, and represented an addition of 0·05% chromium and 0·025% magnesium.

Results:—The copper poured splendidly into the sand moulds and it "lay" very quiet; heads and ingots concaved and corrugated (a sign of solidity). The castings externally were bright and clean, this test was repeated with like results.

EXPERIMENT No. 2.

Electrolytic copper	10,000 grms.
10% chromium copper	75 ,,
10% magnesium copper	25 ,,

Results:—Excellent; Chromium was judged as being a high as external colour of castings was a little dark. (Note chromium darkens copper externally when the latter is cast in sand).

A large number of these tests were made, and the greater part were successful. Therefore a copper bar 24 in. long, by ¾-in. diameter was cast in sand for conductivity measurements. The chrome-magnesium deoxidizer was tested against the following deoxidizing agents.

Bar marked "A" deoxidized with silico-calcium copper, consisted of 10% silicon copper, 75%; 10% calcium copper, 25%; used, 0·25%.
Bar marked "B" deoxidized with 0·05 chromium; 0·025 magnesium.
Bar marked "C" deoxidized with 1% of General Electric "Boroflux."
Bar marked "D" deoxidized with 1% calcium carbide and 1% calcined borax.
Bar marked "E" deoxidized with 0·5% calcium boride.

RESULTS OF TESTS.

Bar "A" conductivity, 75%.
Bar "B" conductivity, 78% chromium-magnesium alloy.
Bar "C" conductivity, 75%; General Electric.
Bar "D" conductivity, 75%.
Bar "E" conductivity, Casting spongy.

The combination chrome-magnesium was also tested in yellow brass, gun metals (88–10–2), red brass and in other common alloys, and in all cases seemed to be an excellent deoxidizing alloy. Another combined alloy was then tried as follows; 10% chromium copper 65%; 10% magnesium copper 35%; Result: Failure as mixture had oxidized in melting.

These experiments indicate that chromium-magnesium in suitable proportions added to the molten bath in such a way that it is immediately immersed in the bath has an excellent effect on copper and its alloys, and has a distinct influence in improving electrical conductivity.

Annual Meeting of Institute of British Foundrymen

The thirty-first annual conference of the Institute of British Foundrymen, held in Manchester recently, provided a further opportunity for the exchange of information and experience which has done so much to develop the foundry industry and improve the status of foundrymen.

CONSIDERABLE development has been effected in the work associated with the production of castings since the Institute of British Foundrymen was established, and much credit is due to the members of this association for the energy and enthusiasm with which the original objects of the founders have been carried on. The work of the founders in the interest of the association was suitably acknowledged at the initial meeting of this conference, and very cordial greetings and good wishes were extended to those who are still active in the interests of the Institute and of the industry. By the courtesy of Mr. J. S. G. Primrose, we are able to reproduce a composite photograph of a group of these original members still on active service.

Group of Original Members still on Active Service. Back Row—Jas. Smith, Jas. Galt, K. M. Burder, D. A. Aston. Second Row—W. H. Sherburn, T. W. Markland, W. R. Wilson. Third Row—Jas. Chadwick, J. T. Goodwin, P. Longmuir, W. H. Meadowcroft. Front Row—R. W. Kenyon, C. E. Williams, F. W. Finch, F. J. Cook, J. J. McClelland.

This Conference was officially opened with a civic welcome from the Right Honourable the Lord Mayor of Manchester, Alderman Joseph Binns, M.B.E., who was supported by Mr. B. Mouat Jones, Principal of the Manchester College of Technology, after which Mr. Roy Stubbs was installed as president of the Institute for the ensuing year. In his address, Mr. Stubbs said the foundry did not rehash something that had already been made; he creates something new every time a cast is made. He commented on the rapid development of mechanisation in the foundry, and repudiated the idea prevalent in some quarters that the machine-made article is inferior to those made by hand. Since the introduction of machines, there has been a steady and continued improvement in the standard of output of every commodity that helps to make life brighter. Despite the progress made in the science and art of casting production, Mr. Stubbs expressed concern that young men did not rush into the foundries nowadays. The best foundrymen, he said, are of middle age or older, and yet no industry can continue unless it builds up a generation of young men. We must bring large numbers of young men into this industry, we must show them its attractive features, we must train them into the knowledge and skill which we possess, otherwise we shall find ourselves falling behind in our ability to satisfy the increasing demands necessary to meet society's onward progress.

During the course of his presidential address, Mr. Stubbs was able to announce the completion of arrangements between the Institute and the University of Sheffield for the establishment of a degree course in the science and technique of foundry practice. A four years' course, under the general supervision of Professor J. H. Andrew, will lead to the degree, honours and ordinary, of Bachelor of Metallurgy (Founding) and also to an associateship. The Institute has made itself responsible for this new departure, having succeeded in obtaining from the foundry industry promises of financial support for a period of seven years. The course will start immediately on the resumption of the university activities after the summer vacation.

At this meeting the Oliver Stubbs Medal, which is awarded for services to the Institute and to the industry, was presented to Mr. D. C. Faulkner for his efforts towards the establishment of a degree course in founding practice. Other awards made included diplomas for meritorious papers presented at the various branches of the Institute. These diplomas were awarded to Messrs. G. L. Bailey, A. B. Everest, B. Gale, F. Hudson, J. Longden, A. Logan, W. G. Morgan, T. Makemson, and J. Roxburgh. At the conclusion of the business meeting a report of the work of the Cast Iron Sub-Committee of the Technical Committee was presented, in which reference is made to investigations on total carbon and phosphorus in relation to the porosity and strength of cast iron; contraction; carbon pick-up; microstructures, and wear testing. The major part of the report is concerned with an investigation into the theory, which had been expressed in various quarters, that the properties of iron in relation to strength and soundness were at their worst when the phosphorus content was approximately 0·4 to 0·6%, or, in other words, a dangerous range existed at this composition. This subject opened up the very general one of porosity and strength of cast iron in relation to its constituents, and this has occupied most of the attention of the sub-committee. Following a discussion on this report, a contribution to the study of graphite formation and structure in cast iron and its influence upon the properties of the cast metal was presented by Dr. Ing. Heinrich Nipper. This was presented as the German exchange paper, and dealt with various aspects of graphite formation in the light of previous investigations. The method and effect of undercooling the melt on its crystallisation is discussed in a general way as a prelude to a consideration of the question regarding how freezing without and with undercooling operates upon the graphite formation in cast iron. Dr. Nipper stated that this question was divided under three main headings—namely, hypo-eutectic, eutectic, and hyper-eutectic alloys, which he discussed.

Several interesting and informative papers were presented at technical sessions held the following day, brief summaries of which are given under their respective headings.

OVEN-DRYING OF CORES AND MOULDS.

Whatever bond may be used to enable sand grains to adhere and form suitable cores and moulds, a considerable proportion of water is used, and drying or baking is generally necessary before the core or mould is fit to perform its function. Hot air is used for this purpose because it has a great capacity for absorbing water; at atmospheric

pressure and 200° F. 1 lb. of dry air will absorb about 2·3 lb. of water vapour before reaching its saturation point. Mr. E. G. Fiegehen, who discussed this subject, states that the temperature of the air must be regulated to prevent overheating and the destruction of the binders used, and no direct flame or intense radiant heat should come in contact with the cores in the oven.

To dry cores and moulds successfully, without surface cracking, a moderate oven temperature is essential, and it is now recognised that three distinctive stages of drying have to be arranged ; these embrace constant rate drying, saturated surface drying, and sub-surface drying. Greater attention is now given to the design and manufacture of core ovens, and the author deals with modern developments in core ovens and future trends.

RECENT DEVELOPMENTS IN BRITISH SYNTHETIC MOULDING-SAND.

This paper by Mr. John J. Sheenan deals mainly with experience gained in converting the sand systems of a mechanised foundry from natural moulding sands to the use of synthetic moulding sand. The problem was to develop a moulding sand that would operate successfully as a grey iron, a steel and a jobbing floor sand, and further to make the basis of this sand, burnt sand which has already functioned in oil-sand cores. The investigation which has been carried out at the works of the Austin Motor Company has revealed very important surface energy effects between bond and sand grain, dependent mainly upon the physical condition of the sand grain. Further investigations are proceeding, because the synthetic system developed has already indicated further economies and some remarkable possibilities. It is possible, for instance, to burn on the sand grain many materials which will increase the surface tension between sand grain and bond, and increase the green and dry bond strengths of the sand ; manganese compounds are one example. These are manganese resinate, which, added to linseed oil bond will decrease the drying time of the core. Manganese compounds will be burnt on to the grains by the heat of the metal on the cores, and subsequently by the heat of the metal on the moulding sand. In steel moulding, manganese silicate will be formed at the surface of the mould, and the stripping of the casting made to resemble or improve upon the easily-stripped moulds in manganese steel castings. Mr. Sheenan claims that the results of such additions are economy in the core shop, economy in clay bond, economy in the fitting shop.

The burning-on of aluminium hydroxide to the sand grain suggests even other advantages apart from its desirability as a refractory and its suitability as an addition to siliceous clay binders, such as gelatinous compound, should have high surface energy effects. Only results are given in this paper that the author has repeatedly confirmed He is convinced, however, that used sand is in a better state for further use than new sand.

THE USE OF HIGH-DUTY CAST IRON IN THE MANUFACTURE OF TEXTILE MACHINERY

Mechanical engineers have been led of late to pay greater attention than in pre-war years to the researches carried out by metallurgists in the realm of cast iron. The application of these researches soon had the effect of bringing about notable improvements in the mechanical and physical properties of the material. The influence of two important factors have been ascertained—namely, the constitution of the metal and its structure. With fuller knowledge of these factors, high-grade cast iron has been used in the manufacture of heavy machine parts. It was soon found advisable, however, to apply the developments to the lighter range of machine parts, and especially to spinning and weaving machine parts, such as worm gears, intersecting and self-acting spool mechanisms, levers, calender and fluted roller gears, brake pulleys, etc., for which high-duty cast iron is being increasingly applied.

The subject is discussed in the French exchange paper by M. A. Roeder, who states that the superior quality of high-duty cast iron ensures a higher resistance to tensile and bending stresses and to shearing and impact stresses ; it also confers to the pieces a considerably higher fatigue limit. It should be noted in this connection that some component parts of textile machinery have to undergo in service endurance stresses having varying rates of high frequency, stresses the direction of which is constantly alternating between extensive positive and negative values. Hence, the builders of textile machines have taken great interest in the very high increase in fatigue limit here referred to, and are using machine parts made of high-duty cast iron. An important consideration in their use is that these castings are highly resistant to wear. The results of tests given in this paper clearly show the superiority of castings from special brands of cast iron in comparison with those formerly used for castings for spinning and weaving machines, and is claimed to contribute considerably to the progress achieved in the construction of textile machinery.

STUDIES ON CAST RED BRASS FOR THE ESTABLISHMENT OF A BASIC CLASSIFICATION OF NON-FERROUS INGOT METALS FOR SPECIFICATION PURPOSES.

The research discussed in this paper, which is restricted to red brass having a nominal composition of 85% copper and 5% each of tin, zinc, and lead, forms part of an investigation which was sponsored by the Non-ferrous Ingot Metal Institute at the Bureau of Standards of the United States Department of Commerce to collect data to be used in the simplification of the number of compositions of copper-base ingot metals. It was presented by Mr. C. M. Saeger, junr., as the American exchange paper.

In this research a comparison was made of the alloys made from virgin metal and remelted metal with four distinct types of test-bars cast at temperatures from 1,040° to 1,260° C. The results for tensile strength, Brinell hardness, electrical resistivity and density divided the test-bars into three classes :—(1) Bars from chill ingots ; (2) bars from ingots obtained by the " immersed crucible " method ; and (3) sand-cast bars. There were only slight variations in the values obtained from any type of bar cast from virgin or remelted metal. The shrinkage and the running properties of the alloy were also determined. The metallographic structure of the bars poured at 1,205° and 1,260° C. led to the conclusion that, in general, a marked columnar structure is accompanied by inferior physical properties. Pronounced non-uniformity of structure was found in one type of sand-cast test-bar. Microscopic examination showed that sand-cast bars poured at high temperatures were subject to high stresses during the cooling, and had inferior physical properties. An expansion of the alloy occurred immediately after solidification.

In the second phase of the work the separate effects of sulphur and iron were studied. Casting at a high temperature lowered the physical properties more than did the addition of sulphur up to 0·1%. The addition of iron up to 0·6% improved all of the physical properties of this brass with the exception of the electrical resistivity. The running properties were improved, and the shrinkage was unchanged by the addition of either sulphur or iron.

It is shown that the pouring temperature affected the properties of all the test-bars much more than any other factor. In general, the best results for the sand-cast bars were obtained with a pouring temperature below 1,205° C. These effects of pouring temperature on the physical properties of test-bars were the same for alloys containing either sulphur (maximum 0·10%) or iron (maximum 0·6%). The physical properties of test-bars poured at 1,150° C.

or below were not appreciably affected by the presence of sulphur up to 0·10%. In bars poured at higher temperatures 0·10% of sulphur adversely affected the properties, particularly of the sand-cast bars. Additions of iron up to 0·6% had similar but much less pronounced effects.

The detrimental effects of high pouring temperatures and of impurities were much more pronounced in the sand-cast bars than in the other types. The non-uniform grain structure of the sand-cast bars and the existence in them of a strained condition during cooling are probably related to these effects. The flowing properties increased with the pouring temperature. The presence of sulphur, up to 0·10%, improved the flowing properties, while iron had no consistent influence. Similar statements apply to the shrinkage.

A comparison of the results for tensile strength and hardness with the minimum requirements for this alloy in ingot form set forth by the American Society for Testing Materials shows (*a*) that the end-gate sand-cast bar is unsuitable for low pouring temperatures; (*b*) that, with this exception, all sand-cast bars of virgin or remelted metal poured at a temperature not exceeding 1,205° C. easily meet these minimum requirements; and (c) the presence of sulphur up to 0·10%, or of iron up to 0·6%, is not objectionable in sand-cast bars. The adverse effect of pouring temperatures above 1,205° C. was not so pronounced in the chilled-ingot and other bars as in the sand-cast bars. The relatively wide variation in the physical properties of different types of test-bars obtained from the same heat of metal forcibly emphasises the need for a standard method for obtaining the test-bars. In many respects the sand-cast bars were not so suitable as those obtained by other methods.

STUDIES IN CAST BRONZES.

This paper by Mr. Francis W. Rowe is the result of an investigation in an effort to determine the precise effect of variations in composition of cast bronzes on the physical properties and the effect of mass under various conditions of casting. In cast bronzes for engineering use, the amount of tin varies from about 5% to a maximum of from 15 to 16%. The two other constituents usually present in varying quantities, besides copper, are zinc and lead, and to a lesser extent nickel. Where the cast bronze is needed for anti-frictional or wear-resisting purposes, zinc should be absent, in which case phosphorus is added sometimes purely for deoxidising purposes and also sometimes for increasing the hardness and the anti-frictional and wear-resisting properties. It may be present in quantities varying from 0·3 to 1·4%. Where the bronze is required for these duties, lead may be added in amounts varying from 1 to 15% (or in certain specific instances as high as 20 or 30%) to increase the plasticity of the alloy and increase its fitness for its work in certain conditions. In this paper, however, tin and phosphorus are considered only as alloying elements.

The author briefly interprets the copper-tin equilibrium diagram, and discusses the alpha-delta eutectoid which is present in all cast bronzes made under normal conditions in which the content of tin exceeds about 5·5% and is less than 28%. Varying quantities of this compound materially affect the physical properties of the bronzes. Apart from the differences in bronzes which arise from different compositions, large difference may be present, due to casting condition and mass of the casting. Experimental data are given covering tests on a series of compositions. To avoid confusion, all variations to melting conditions, gas, and oxide content and deleterious impurities have been eliminated, but the results quoted are from initially pure metals melted under good average foundry conditions, and the resultant bronzes contain neither more nor less amounts than normally obtain of oxide, gas, or deleterious impurities when using virgin raw materials. Six series were investigated and the physical tests from these are given.

WORKS VISITS.

In addition to the technical sessions, considerable interest was displayed in the various works visits arranged. These included the Openshaw Works of Joseph Stubbs, Ltd.; Metropolitan Vickers Electrical Co., Ltd.; Craven Brothers (Manchester), Ltd.; Leyland Motors, Ltd.; the Lancashire Steel Corporation, Ltd.; and Tweedales and Smalley (1920), Ltd. Each was exceedingly well supported and proved to be both interesting and instructive, not only to the visitors but to those who were responsible for their cordial reception, because the interchange of information was coupled with suggestions that are frequently of distinct advantage in the works visited, and it is rarely indeed that visits of this kind do no tprove fruitful to both the visitor and the host.

Edgar Marburg Lecture.

The ninth Edgar Marburg Lecture will be delivered by Sheppard T. Powell, Baltimore, at the 1934 annual meeting of the American Society for Testing Materials to be held in Atlantic City, N.J., June 25 to 29. His subject will be "Water as an Engineering and Industrial Material." This lecture, which brings an outstanding scientist before the A.S.T.M. each year, commemorates this Society's first secretary-treasurer, who, through his development of technical programmes over a period of sixteen years, brought wide recognition to the Society as a forum for the discussion of various phases of materials used in engineering. The lecture further emphasises the importance of the Society's work in promoting the knowledge of engineering materials.

Mr. Powell, who is an outstanding authority on water and its problems, will review briefly the uses of water in engineering and industrial projects, stressing the variety of specifications required to meet the varying demands. He will outline specific requirements in different industries and discuss the advances in the art of water purification. The problem of testing forms a large portion of the lecture, especially analytical procedure. A brief survey of the current research in this country and abroad will focus attention on the potential value of petrographic, spectrographic and other applications of analytical procedure.

For many years Mr. Powell has been retained in a consulting capacity by a large number of companies and municipalities in reference to the treatment of water for domestic and industrial uses and the treatment and recovery of trade wastes. As the author of a great number of technical papers presented before many societies, he has discussed such problems as operation and control of boiler feed water purification systems, embrittlement of boiler steel, the corrosion of casings of water wells by electrolysis, corrosion inhibition by lime treatment and its effect on industrial water consumption costs, etc. He is chairman of the Joint Research Committee on Boiler Feed Water Studies, and also of the Joint Committee on Stream Pollution. He is a member of the A.S.M.E. Boiler Code Committee, A.S.T.M. Committee D–19 on Water for Industrial Uses, chairman of the Four States Section of the American Water Works Association and past-chairman of the Maryland Section of the American Chemical Society.

Soviet Russia's 110th blast-furnace was blown in January 17, when the third stack at the Kuznetsk plant in Siberia was lighted. The first two stacks at Kuznetsk were built under supervision of the Freyn Engineering Co., Chicago. The fourth stack at the Magnitogorsk plant in the Urals was completed December 31.

The Classification, Properties, and Utilisation of Non-Ferrous Scrap Metals and Alloys.

By A SPECIAL CORRESPONDENT.

The wide variety of non-ferrous alloys now employed, and the increasing need for accuracy in their composition, creates a very real difficulty in their proper utilisation when the articles for which they have been used become scrap metal. In this and subsequent articles the author discusses the problem with a view to the more profitable use of scrap metals and alloys.

Copper and Copper Bearing Materials.

THERE are a great variety of scrap materials consisting principally of copper in various forms, and there would not be the space in the present article to discuss fully all of such. Only those, therefore, of principal commercial interest will be discussed. As is well known, the purest form of copper is electrolytic copper which, in the form of cathode sheet, is recognisable by the peculiar appearance of the surface, which is rough where it has grown in contact with the electrolyte. Electrolytic copper in the form of cathodes rarely appears on the Scrap Metal Market, except perhaps in very small amounts. A considerable amount of copper, which is referred to as re-melted electrolytic copper, is, however, met with. Such material may or may not actually have been electrolytic copper, since it is almost impossible to tell even by analysis of the ingots of such material after it has been melted whether the original copper really was electrolytic, or whether this name has merely been applied to it to enhance its commercial value. A good deal of heavy copper scrap appears upon the market in the form of castings, but it is not safe to use this material directly for the production of castings for the electrical trade, because such copper may not be at all pure. The casting of copper soundly is a matter of some difficulty, and it is usually necessary to add to the metal some silicon, phosphorus, tin, zinc, or arsenic, in order to make it cast sound, especially in thick heavy castings. Such material must, therefore, be regarded with suspicion and analysed before use.

Copper Wire.

Copper, which is in the form of trolley wire, can generally be relied upon to have considerable electrical conductivity, and may be used for the production of parts which are required to have high electrical conductivity. The fact must not be overlooked, however, that the use of cadmium in copper for trolley wire is extending considerably, and trolley wire which is purchased at the present time may easily contain up to 0·5% of cadmium. The cadmium is added to the trolley wire to increase the tensile strength and resistance of the wire to wear; the cadmium does not appreciably deleteriously affect the electrical conductivity of the wire. For some purposes, however, it may be undesirable to have cadmium in the metal. In crucible melting trolley wire is usually cut into short lengths so as to extend about one-third above the top of the crucible when tightly packed in. In this way a full pot of molten metal will be obtained without charging additional wire during the melting process. A deepener should be provided upon the crucible and in it should be placed upon the top of the copper a few lumps of hard wood or charcoal. It is often preferable to use simply the hard wood which, by burning away, will generate flames and so keep furnace gases out of contact with the metal during its initial melting stages. Should it be necessary during the melting operation to add additional pieces of copper, it is most essential that they should be warmed before charging into the molten metal, otherwise explosions may result due to moisture condensed on the wire being entrapped beneath the surface of the molten metal and projecting it from the crucible. In order to deal with springy wire it is essential to anneal it before it is balep in a baling press; this will make the wire malleable and enable it to be compressed into ecmpact blocks for handling in the crucibles. If it is not annealed before baling it will be very difficult to compress.

Copper Clippings.

Copper clippings from sheet metal working tend, owing to the large exposed superficial surface, to oxidise rather seriously; it is, therefore, necessary to treat the molten metal with some de-oxidiser, such as phosphor copper. The phosphor copper may be added to the extent of about 0·25% of the 15% phosphor copper alloy. This will prevent the production of porous castings if the copper is used for making castings without the addition of any other alloying element. Copper which is obtained from the armatures of electro motors and dynamos—that is to say, copper segments—very often contain silicon, and this fact must be borne in mind. Silicon in copper to be used for castings gives a rather dirty appearance, and for that reason is to be avoided where possible. Aluminium also in small amounts gives dirty castings of pure copper, but on the other hand aluminium is never used for de-oxidising copper, so that it is not likely to be met with. Silicon present in copper which is to be alloyed with zinc for the production of brass, will react with any lead which may be present, either accidentally or intentionally added to form lead silicate, which gives a rather dirty scum and the whitish dross upon the surface of the castings made from such material. The mica which is often associated with copper segments from armatures does no harm whatever to the copper during the melting operation, although it may often be present in such material and also in copper turnings or swarfs from the manufacture of commutators.

Alloying Elements in Copper Wire.

It should have been mentioned above that in discussing trolley wire telephone wire also is very often not quite pure, but contains from ½ to 1½% of tin in order to increase the tensile strength. Such material is, therefore, unsuitable for the production of high conductivity castings, in copper. In melting copper it is always necessary to use fuel which is free from sulphur, because copper has a great affinity for sulphur, and should sulphurous fuel be used the copper will tend to contain copper sulphide, and its properties will be to some extent deleteriously affected. Wire which has been obtained from small electro magnets and other sources, such as hair wire—that is to say, very fine wire—may often contain sulphur. This can be recognised if the wire has been burnt off—that is to say, if the insulation has been burnt off the wire, as is often done by scrap metal dealers in order to reduce the space taken up by the material. The burning off of the insulation tends to expose the wire to a high temperature and at the same time to sulphurous fumes from the rubber coating. Such wire is always brittle and the brittleness is a sign of the fact that the wire contains sulphur.

Castings made from such material would tend to be blown and to be porous, because of the formation of sulphur

dioxide by combination of the oxygen of the copper oxide and of the sulphur during the time that the castings are setting or solidifying in the mould. The same holds good even when the copper is used in the production of brass. Such material may be treated by maintaining it molten for a long time, whereby the copper oxidises superficially and the sulphur burns off. After such material has been ingotted and remelted with calcium carbide in the bottom of the crucible the metal is much improved. If, in addition, such copper should contain iron, the iron combines with the oxygen forming ferrous oxide, and if sand is then thrown upon the surface ferrous silicate will form, which is a fusible slag and can be skimmed off. In this way the bulk of the iron and oxygen may be eliminated from the copper, but the sulphur is very difficult to remove, since it has a great affinity for the copper. Thin wire, such as hair wire or telephone wire, must be melted as quickly as possible so as to expose it to the oxidation of the atmosphere for as short a time as possible. It is generally preferable to refine hair wire and thin telephone wire in the refining process for copper rather than to use it as a melting material for the production of alloys or ingots since the melting loss by this latter process is so excessively high. Should telephone wire be used for the production of bronze, it is advisable to add in the bottom of the crucible 0·25% of 15% phosphor copper, and in making brass from such material it is advisable to add 5 oz. of manganese copper, 30% manganese, remainder copper for the purpose of deoxidation.

Miscellaneous Copper Scrap.

A good deal of copper is obtained from the printing industry in the form of printing blocks of various kinds. Electrotype, stereotype, and linotype shells are copper which has been stripped from the white metal and the wood backing of printing blocks. Such copper is usually rather impure and contains about 30% of lead, 2% tin, and 5% of antimony, which is not easy to remove in the separation of the backing from the actual electrolytic copper surface of the printing block itself. Such an alloy is not satisfactory for production of castings, and it is best to have it refined by a smelter. A certain amount of material, mainly of lead-copper basis, appears upon the market from various sources, and some such compositions are known as dry pot metal, which is composed of copper 64%, and lead 36%, to which arsenic was often added to kill the lead—that is, to make it remain in solution in the copper. Another name for this alloy was cock alloy. Actually this composition is practically that of plastic bronze, the colour of which is almost indistinct from ordinary tin bronze, especially when there is a small percentage of tin present in the plastic bronze. The fact that it is so much heavier, however, on account of the lead content gives an indication of the true nature of this material and often serves as a means of distinguishing it. It may also be recognised by its softness under the hammer, and also by the fact that on heating up to approximately a red heat, beads of lead exude from the material when it contains 20% or more of lead. This exudation of beads of lead occurs at a much lower temperature than would the exudation of tin known as tin sweat from bronze.

Yellow Metal Scrap.

Ordinary yellow brass of about 70 : 30 composition is readily recognised on account of its yellow colour, especially in machine surfaces. It is not easy, however, to distinguish the 60 : 40 alloy from ordinary tin-bronze since the colour of these two is so nearly alike. Various kinds of bronze, such as aluminium-bronze, tobin-bronze, and manganese-bronze, are used in some applications where specially high strength is required. Such materials are not used as bearing metals. These points assist the sorter in classifying such material which, on account of similarity of colour, is otherwise rendered very difficult. The application of the material thus forms a certain guide which can be used to some extent for classifying such scrap materials. Heavy engine bearings are generally composed of from 11–13% of tin with a little zinc and a trace of lead, and the remainder copper. Small bearings and bushes are generally of 80% copper, 10% lead, 10% tin. It is generally safe to regard valve stems, machinery bearings, and pump parts, and also other bars which are exposed to air or hydraulic pressure, as good sound material. They are often composed of red brass. Aluminium brass is generally rather high in zinc and, of course, only contains a very little aluminium. The aluminium is added in order to make the material run very fluid in the mould so as safely to reproduce the finest impressions thereof. Such high zinc alloys generally show a greenish colour when they are held hard against an emery wheel. This is due to the fact that such material heats up very rapidly and is only abraded with extreme difficulty on account of its hardness. This greenish colour or tint is also noticeable upon the outer skin of metal which has been extruded. Such extruded alloys hardly ever contain aluminium, but are usually very high in zinc, containing this element up to about 45%. Alloys containing up to 45% of zinc are not very satisfactory for sand casting unless a certain amount of aluminium to the extent of perhaps 0·1% has been added. In order to use up brass scrap which contains a certain amount of aluminium, say, not in excess of 0·5%, it is generally necessary to make a few experimental heats with various additions of the aluminium bearing brass to good clean metal in order to see how much can be added without spoiling the appearance of the resultant castings. Generally it may be safe to add from 5–10% of aluminium brass scrap, which contains 0·5% of aluminium in such alloying operations. When the aluminium is present in excess of the required amount it will show itself in the form of a white powder upon the surface of ingots, and also the ingots will have a shiny surface instead of the usual chocolate-coloured surface. Cocks or valves are usually composed of good red ordinary brass and do not contain any aluminium. The same applies generally to machinery bearings, but it is necessary to use with caution materials which may contain high amounts of lead. The lead is usually distinguishable by fracturing the alloy when the lead shows up in the form of little grey particles distributed throughout the fracture.

To be continued

Industrial Instruments.

The Electroflo Meters Company have recently completed the supply and installation of a comprehensive scheme of control instruments at the works of Improved Metallurgy Limited, Avonmouth. The installation comprises multipoint temperature indicators of the thermo-electric type, multiple temperature recorders, fitted with the Electroflo continuous roll charts, instruments being mounted on steel panels and complete with thermocouples. A subsequent order comprised the supply, delivery and erection of 18 draught and pressure indicators and recorders, Electroflo transmitting CO_2 analyser electrically operated and recorded—the instrument again being mounted on an attractive steel panel.

"Shorter" Process.

We have pleasure in announcing that The Patent Gear and Metal Hardening Co., Ltd., has just concluded an agreement with the Linde Air Products Company, of 30, East 42nd Street, New York, for introducing the "Shorter" process of metal surface hardening to the American market. The Linde Air Products Company will deal with all enquiries in the United States and Canada, and will shortly be in a position to offer standard "Shorterizing" machines for operating the process.

It is noteworthy that an arrangement was recently made with I. G. Farbenindustrie for Germany and other Continental countries and the Company now have a wide organisation whereby the benefits of the "Shorter" process can be obtained in almost all parts of the world.

Association of German Metallurgists

Many interesting subjects were discussed at a meeting of Verein deutcher Eisenhuttenleute, held in Dusseldorf on June 2 and 3, and the following summaries of some of these subjects indicate the trend of thought on current problems.

INFLUENCE OF VARIOUS ELEMENTS ON PRECIPITATION PROCESSES IN STEEL.

By Prof. Dr.-Ing. E.h. W. EILENDER, AACHEN.

IT has long been known that, with steel as with non-ferrous metals, precipitation of the excess of dissolved elements on standing, or more quickly on tempering, strongly affects the hardness, coercive force, remanence and electrical conductivity. Only in recent years, however, has it been established which elements are of importance in connection with precipitation hardening; above all, carbon, nitrogen, oxygen and copper are so regarded. So far as the injurious effects of ageing are concerned, it was uncertain whether oxygen or nitrogen was responsible for these.

To investigate this problem more closely, the purest possible iron test pieces, to which only the element under investigation was added, were melted in high frequency vacuum furnaces at the experimental laboratory of Fried. Krupp A. G., Essen, and at the Iron Foundrymen's Institute at the Technische Hochschule, Aachen. These test pieces were annealed at 900 to 930° C., cooled in air, re-annealed at 600 to 680° C., quenched in water and then tempered at various temperatures. The precipitation phenomena were followed by measurements of the electrical conductivity, the coercive force, remanence and Brinell hardness in relation to the temperature of tempering.

Steels containing carbon, nitrogen or copper showed,

(1) that the greatest change in the various physical properties occurred at different tempering temperatures, *i.e.*, that these properties were influenced by the size of the precipitated particles;

(2) that the capacity for precipitation can be influenced, or even suppressed, by additions such as occur as impurities in commercial steels, or are purposely added to improve the properties.

With greater probability it could be shown that oxygen caused no precipitation hardening. It should not, however, be asserted that no ageing can occur on account of oxygen. This is mainly dependent on the size of the precipitated particles; as the oxide inclusions separate before or during solidification, they are generally present in particle sizes on which mechanical ageing has no further effect. On the other hand, the possibility of the interaction of oxygen in the precipitation of other metals is not to be rejected.

Further investigation of the dynamic effect figures in pure iron containing only nitrogen or oxygen, showed that in the presence of oxygen alone no figures appeared, that the strength of the figures with nitrogen steels was dependent on the temperature of tempering and also on the size and distribution of the precipitated material, and that by special additions the appearance of the figures could be hindered, if the tendency of the steel to precipitation was reduced by the addition. Essentially the conclusion to be drawn from the experiments is that the metallurgy of nitrogen is of practically decisive importance in the production of steel insensitive to ageing.

TECHNICAL DEVELOPMENTS IN AMERICAN SHEET ROLLING MILLS.

By H. KLEIN, SIEGEN.

The demands of the sheet-using industry for ever-improving quality of material, and the desire to produce larger quantities than before with lower costs, led to ways and means being sought to overcome the failings of manual labour and the faults of existing plants, and to the adoption of mechanical devices.

After prolonged experiments the Americans succeeded in producing sheet on so-called continuous rolling trains by hot-rolling. The new arrangement differed from the customary one, mainly in the fact that the housings were placed one behind the other, instead of side by side, at comparatively short intervals. The sheet so obtained was not only the finished product, but also raw material for further working on other trains, of either hot- or cold-rolling mills.

The first train of this type consisted of 14 housings, on which—starting from the ingot—sheet was rolled and sheared in one operation to 750 mm. wide by 1·6 mm. thick, to 1,000 mm. wide by 1·8 mm. thick, to 1,100 mm. wide by 2·0 mm. thick, to 1220, mm. wide by 2·4 mm. thick.

For sheets 1·7 to 2·4 mm. thick, the output was 75 to 100 per hour. These hitherto unheard-of amounts can only be obtained by such carefully planned arrangement of furnace and rolling train that time-consuming manual labour, and its accompanying irregularities and inaccuracies are eliminated. At the same time the cost of conversion of ingot to finished sheet was considerably lower than for the production of similar sheet with the old type of rolling mill.

In course of time more than a dozen of these continuous sheet and bar plate trains have been erected in America. Their extraordinary capacity and low production cost made them, with good trade, dangerous competitors for mills of the old type. Mills which fought shy of the high initial outlay on a continuous train were constrained to attempt on the one hand a reduction in production costs by the use of mechanical devices in the individual working processes, and on the other hand an improvement in quality by the elimination as far as possible of errors due to manual labour. Their efforts were successful. Not only was output considerably increased, but the quality of the product was so improved as to win it the best reputation in the world's markets.

Improvements in rolling mills of the old type extended in the first place to the heating of the bars and pairs in a so-called "pacemaker" furnace, in which the (hot) material passing through was subjected to exactly regulated temperature from input to output end. In addition, special transporters were built to carry the billets and pairs to the rolls and to bring the piles or pairs to the furnace. In front of and behind the rolls were arranged automatic tilting tables with transporting chains for introducing and catching the material. Automatic setting of the pressure screws, a special device for measuring the sheet, and finally the mechanical doubler, are new devices characteristic of the improved method of working.

These improvements were explained by the speaker with the aid of numerous photographs. He showed by this means the underlying efforts which resulted in cutting out the errors due to manual labour, in the improvements in quality of the material, as well as in increasing production and reducing prime costs. The speaker then surveyed the ordinary rolling process as at present carried out in the United States, and mentioned also the recently introduced Steckel strip mill.

The conclusions, as applied to German conditions, may be summarised thus—the efforts of the American sheet mills, which with small means sought to improve the quality of their products and the economics of their plant, deserve fullest consideration. In particular it is necessary

to get rid as far as possible of the failings of the present method of working and to reduce production costs. This effort is of the greatest importance, especially when it is a case of the export of sheets which have to meet the competition of foreign products in the world's markets, and should therefore yield a certain profit.

DEVELOPMENTS OF ELECTRICAL TOOLS FOR INDUSTRY, PARTICULARLY FOR THE FOUNDRY.

By Dr.-Ing. E.h. R. BINGEL, BERLIN.

In the applications of electrical engineering to industry, certain lines of development stand out in the several spheres of lighting, heating and power transmission, and these are most marked in the extensive field of power transmission. This development first showed itself in the constructional excellence of motors, the perfection of switchgear and then in the ever closer adapation of electrical drives to the many-sided demands of industrial production. Thus the most difficult drive problems were overcome, as indicated to some extent by the catchwords "Revolution adjustment" "Equal running" applied to single and multiple motor drives. This highly significant development in production technique can, in relation to its direction, be most generally formulated thus—production is constantly striving, by the increasing application of electrical engineering devices, to do away with accidents brought about in individual processes by energy, technical or human agency. The most significant end link in this line of development is the "Electrical work machine" (Elektroarbeitsmaschine) in which the problem of internal transmission is solved by fitting a series of individual drives, so that the transformation of energy takes place as near as possible to the direct working shaft, thus dispensing with all unnecessary transmission links.

In pursuit of this question it is worth while considering what restraining forces have stood in the way of development—*e.g.*, clinging to tradition, fear of unsuitability in practice, self assertion of a manufacturing department, outstripped by technical development, etc.—and on the other hand, what driving forces are available to overcome more and more successfully these restraints and resistances. Among these driving forces a significant part has been played by the mutual improvement of industry and electrical engineering, which has been particularly noticeable in the iron foundry industry, and electrical engineering in the production of new and highly valuable materials for their bilateral needs.

This development of modern electrical engineering has in recent years been enriched by novel and very promising tools, the light cell, the valve, the screen-controlled rectifier, the oil-less or low-oil switch, which have already been applied to a number of problems with good results.

In this new region there has established itself as one of the most important pacemakers in development the property of easy and exact measurability by means of the electrical energy effect; continuous measurement in finishing processes, with the finest instruments, such as light cells, bolometers, pressure gauges, etc., serves as key and tool for the automatic control of working processes which could not be carried out with such fineness and accuracy with the implements previously available.

Further development will probably proceed along the lines of this type of improvement—without any revolutionary novelties. Such an improvement in production—be it in the preparation of the raw material, or in highly developed after-working—must be furnished with the newest electrical engineering appliances, and will give us an advantage over other countries when we wish to secure to ourselves urgently necessary exports. Hence scientific research should be started immediately on as wide a front as possible, and its efficiency improved as much as possible. A heavy task falls to the organised closed combines in the industry, which are called on to provide the technical and scientific cross-link by passing on their experience and research results to the individual industrial spheres. In particular, electrical firms, which co-operate in all branches of industry, can be of all round assistance in the greatest possible measure by ruling out parallel and double work. Most important are a confidential co-operation between other industries and electrical engineering and a clear statement of the industrial problems and of the possibilities which electrical engineering can offer now and in the future.

THE SPHERE OF THE MODERN ATOMIC THEORY.

By Prof. Dr. W. HEISENBERG, LEIPZIG.

Starting from the old conception that science and technical progress mutually influence each other, the speaker gave a brief outline of the sphere of the modern atomic theory. Two different aspects of this modern science are of importance to its understanding: on the one hand atomic physics gives a clear geometric picture of what happens "in miniature" in many physical and chemical processes; crystal formation or the explanation of chemical reactions are examples of this. On the other hand, the acceptance of (the idea of) the smallest "bricks" of matter forces us to the conclusion that atoms are governed by laws different from those of ordinary matter, and that they are therefore no such definite objects as are the things of daily experience. The existence of stable atoms, deflection of electrons and the possibliity of valency formation, serve as examples of the indistinct outlines of modern atomic physics. To these also belong those forces which are in the main answerable for the magnetism of iron and for "ferromagnetism." These forces may be regarded as "negative valency formation," which causes the magnetic moments of the individual iron atoms to arrange themselves parallel to one another in a direction defined by external forces. Atomic physics can establish mathematically the conditions under which ferromagnetism occurs. It follows that ferromagnetism is not a property of definite chemical elements, but is connected with the reciprocal action of the atoms, *i.e.* an alloy of non-ferromagnetic materials may well be ferromagnetic itself, and further, of the same chemical material, one modification may be ferromagnetic, the other not. The technically important properties of magnetic materials—such as remanence, coercive force, hysteresis—appear as secondary disturbance effects dependent on the pure magnetic reciprocal forces of the atomic magnets. The theoretical investigation of these "disturbance phenomena" has important practical consequences in the technical production of materials with definite prescribed magnetic properties.

In conclusion, the importance of the co-operation of technical and pure science was again mentioned. In Germany this co-operation is based on long tradition—to the advantage of both sides—and it is to be hoped that it will continue in the new Germany.

Monel Metal Wire Gauze.

An unusual use of wire gauze, for which Messrs. Riddell, Cousland and Co., Ltd., have just received an order for 10,000 sq. ft. of Monel Metal gauze, 16 mesh × 35 s.w.g., occurs in connection with the water cooling of volatilisers at the Clydach (South Wales) Refinery of the Mond Nickel Co., Ltd.

The volatilisers are tall vertical chambers in which nickel matter is brought into contact with carbon monoxide to form nickel carbonyl—a gas which is afterwards caused to dissociate with deposition of nickel. The reaction which takes place in the volatiliser is an exothermic one, and the heat evolved must be dissipated to maintain a temperature of about 50° C. This is achieved by allowing water to flow down the outside of the volatiliser, the cooling water being kept in close contact with the surface by means of Monel Metal wire gauze draped around it and secured by wire.

This method has been found satisfactory in cooling the apparatus to the required temperature.

The Iron and Steel Institute

The sixty-fifth annual meeting of the Iron and Steel Institute held in London recently was attended by members from all parts of the world. Considerable enthusiasm in the work of the Institute was manifest, and there was ample evidence of the encouragement given to research with a view to the improvement of practice in the iron and steel industries and also the improvement of their products.

IT is doubtful whether any single institution has done more to encourage research than the Iron and Steel Institute. During the last 65 years it has been instrumental in recording in its journals the majority of the important work accomplished in the iron and steel industry during that time. The original policy of keeping abreast of developments in practice, as well as making progress in materials, has been maintained, and both the scientist and the practical man have similar opportunities for giving the results of his research or experience, and for obtaining the benefit of the research and experience of other members. The results of many important studies have been presented to its members during this long period, the most recent being the second report of the Corrosion Committee which was presented at this meeting.

The problem of corrosion is very complex, but the aim of this committee is to discover the causes that set up corrosion under widely different conditions. Exposure stations at home and abroad have been set up to investigate atmospheric corrosion, while the results of the investigation into marine corrosion will have considerable influence in the shipping industry. It is not possible to deal with the results of this investigation here owing to lack of space, but in the five years this committee has been at work valuable results have accrued, and it is hoped to refer to them in a later issue. Many valuable papers were presented which embrace the two main fields of research previously mentioned, brief summaries of which are given under their respective headings.

In his presidential address, Mr. W. R. Lysaght commented on the remarkable developments made in the British Dominions, particularly in regard to iron and steel works. New works are springing in countries like Australia, New Zealand, and South Africa, which will have a serious effect on the exports from Britain. Although it will be some time before the market in the centre of South Africa is covered, Mr. Lysaght said he was afraid that British iron and steel exporters would have to wipe Australia entirely, and South Africa partially, from their books within a few years.

THE INTERACTIONS OF GASES AND ORE IN THE BLAST-FURNACE.

Part III.—Proposed Methods for Comparative Testing of Iron Ores.

By WILLIAM A. BONE, F.R.S., H. L. SAUNDERS, Ph.D. and N. CALVERT, M.Sc.

A comprehensive experimental inquiry bearing on fuel economy, on the interactions between gases and ore, and on the factors and laws governing both reaction velocities and equilibria in the blast furnace, has been in progress some years under the direction of Dr. W. A. Bone, and some of the results of the investigation have been presented at previous meetings of the Iron and Steel Institute.

Since the publication of Part 1, many blast-furnace managers and chemists have expressed a desire for some reliable laboratory apparatus and procedure for comparing the "reducibilities" of typical iron ores, and in Part III., presented at this meeting, methods are proposed for comparative testing of iron ores. In determining these it was decided that the most suitable criterion for comparative purposes would result from two reactions, namely :—

(1) The carbon deposition resulting from the catalytic reversible $2\,CO = C + CO_2$ decomposition in the upper region of the furnace, particularly at about 450° C.,[2] whereby the ore may be "impregnated" with finely-divided carbon, which at still higher temperatures is known to act very powerfully as a reducing agent ; and

(2) the direct deoxidation of the ore by carbonic oxide—$Fe_xO_y + CO_y = Fe_xO_{y-1} + CO_2$—in the middle region of the furnace, and for comparative purposes a temperature of 750°[3] was selected.

In this connection the authors point out that at neither 450° nor 750° do the two reactions in question mutually interfere to any material extent. For whereas at 450° (1) predominates to the practical exclusion of (2), the case is reversed at 750° and above. To avoid (2) being at all influenced by (1), however, it is necessary for each of the two comparisons always to be made on separate and fresh samples of the particular ore under investigation. They show that by the employment of quite simple apparatus and experimental methods much may be ascertained concerning the characteristics which an ore presents to each of the two main reactions occurring in the blast furnace, and the furnace manager can draw for himself, from experimental data obtained along the lines suggested, his own curves for the particular burden he happens to be working, and may see how these curves are modified by fluctuations in the ratio of the meterials which he charges into his furnace. The economic basis of his iron production depends primarily upon a scientific study of the conditions obtaining inside the furnace, and any step towards this end is one in the right direction.

Part IV.—Equilibria and Velocities in Ore Reduction.

By WILLIAM A. BONE, F.R.S., H. L. SAUNDERS, Ph.D. and J. E. RUSHBROOKE, B.Sc.

In Part II. the subjects of (i) carbon deposition at 450° C.[3] and its influence upon the ore reduction at high temperatures, and (ii) equilibria conditions in the systems $Fe_xO_y + CO = Fe_xO_{y-1} + CO_2$ at temperatures between 750° and 975° C. were fully dealt with ; also (iii) an experimental method and procedure were described for comparing the relative velocities of the ore reduction reactions under conditions prevailing in the blast furnace, as regards both composition of the gases (referred to as "B.-F. gas" in the text) and their speeds of passage over the ore. It is about four years since this part was presented, during which time experimental investigation has been steadily pursued, and the present paper embodies further results which have accrued together with a discussion of their implications in regard to blast-furnace practice. This further experimental work falls into three sections, namely :—

(1) The determination of equilibria in the systems $Fe_xO_y + CO - Fe_xO_{y-1} + CO_2$ at 1,150° C., in completion of the previous work at lower temperatures.

(2) Equilibria in the systems $Fe_xO_y + H_2 = Fe_xO_{y-1} + H_2O$ at temperatures between 450° and 850°, and

(3) Relative velocities of the ore reducing—$Fe_xO_y + CO = Fe_xO_{y-1} + CO_2$—reactions at various selected temperatures between 650° and 1,000°.

Many other matters relative to blast-furnace reactions remain to be investigated, and are included in the authors' experimental programme, yet from the results already accrued, it has become clear that, to obtain full benefit from the research, a systematic exploration of the variation in temperature and other conditions at different levels in a blast furnace under normal working conditions has now become imperative. Indeed, the authors state, the laboratory research, however suggestive and revealing its results, can scarcely be correlated with actual blast-furnace practice until it is known how, in a typical smelting operation, the closely related conditions of temperature, gas composition, and degree of ore reduction vary among themselves, and with the rate of driving, at various levels in the furnace stack. For until such information is forthcoming, the precise interpretation of laboratory results in relation to blast-furnace practice must remain largely conjectural, however significant some of them may be.

THE THERMAL CONDUCTIVITY OF TOOL STEEL.

By DENZABURO HATTORI (Japan).

The investigation discussed in this paper was undertaken to obtain more information relating to the thermal conductivity of tool steels and also to determine the effects of hardening and tempering on the conductivity of such materials. It is shown that with a rise of temperature the thermal conductivity of specimen carbon tool steels had a tendency to decrease, and that of special tool steels hardly change; whereas the conductivity of high-speed steel specimens increased. The thermal conductivity varies with the structure of steels, as follows:—

$$\lambda \text{ aust.} < \lambda \alpha\text{-mart.} < \lambda \beta\text{-mart.} < \lambda \text{ pearl.}$$

In carbon steels, α-martensite changes into β-martensite at about 100°, and then the latter gradually becomes troostite. Hence, the thermal conductivity increased with the rise of tempering temperature up to 200°. At about 250° the conductivity increased greatly, due chiefly to the change of retained austenite into troostite. Above that temperature the amount of troostite increased, and at about 400° the structure became almost entirely troostitic. Accordingly, the conductivity at this temperature was nearly equal to that of the annealed specimens. Results of tests show that in the quenched carbon tool steels the higher the quenching temperature the lower is the thermal conductivity.

It is shown that the conductivity of high-speed steels decreases greatly by quenching, and on tempering it increases a little at 300°, greatly at 550°, and still more at 700° to 800°. Thus, it is claimed, the greater durability, for heavy cutting, of high-speed steel tools tempered at 550° to 600°, as compared with tools that are only quenched, will owe much of this improvement to their better thermal conductivity.

AGEING CHANGES IN NITRIDED STEEL.

By EDWARD G. HERBERT, B.Sc., M.I.Mech.E.

Fluctuating changes in the physical properties of metals, occurring during a period of ageing after severe disturbance, have been observed by many investigators using different methods of hardness testing. These fluctuations did not exhibit any regular periodicity, and the disturbance which gave rise to them does not appear to have been traced, but there was one marked fluctuation in an investigation by Dr. Hengstenberg[1], which, in the light of Mr. Herbert's recent investigations, appeared susceptible of explanation.

Three experiments on nitrided steels are given in this paper and the results confirm the observations of Hengstenberg and are held to throw light on the nature of the phenomenon. It is concluded that when the steel is heated, it is set in a state of periodic fluctuation. When it is cooled, the hot hardness fluctuations tend to persist in the cold metal, but they slow down and eventually damp out. Similar fluctuations can be induced by violent magnetic disturbance, or by cold work. The fluctuations, whether induced by thermal, mechanical, or magnetic means, are susceptible to the influence of magnetism, and are capable of being stabilised by the action of a constant magnetic field, applied at a maximum or a minimum phase.

It is believed that the disturbance, thermal, mechanical, or magnetic, sets up a periodic fluctuation of the interatomic force of attraction, and that this causes corresponding fluctuations in the cohesion between the slip planes and in the resistance which the metal offers to deformation, elastic or plastic. It is believed, further, that the cohesive force between the slip planes is an electromagnetic force. Experiments have indicated that it is capable of being set in a state of oscillation by magnetic disturbance, and that the oscillations can be checked and brought to quiescence by the action of a constant or stabilising magnetic field.

1 O. Hengstenberg: "Variations in the Results of Hardness Measurements of Hardened Steels." *Stahl und Eisen*, 1933, Vol. 53, Apr. 6, pp. 352-355.

TIN-IRON ALLOY IN TINPLATE.

By W. E. HOARE B.Sc.

Discussion of recent work dealing with the practice of tinning steel has indicated considerable diversity of opinion upon such problems, for example, as porosity and mottling, and has demonstrated the need for a more perfect understanding of the fundamentals of the process. The work in this paper which deals with the special reactions of iron and tin during the process of tinplating, forms part of a programme being carried out by the International Tin Research and Development Council. The investigation discussed is limited to the structure of the compound layer occurring in commercial tinplates. It is found that this compound is Fe Su_2, and that no other compound or iron-tin phase of any kind has been observed in commercial tinplates.

Certain defects in commercial tinplate of prime quality have been classified as normal pores, that is, those having the property of true pores immediately the plate leaves the tinning machine, and potential pores, that is those tending to become true pores during the forming of the sheets into commercial articles and together with such defects as blisters, mottle, dry patches, grease lines, and isolated Fe Su_2 crystallites, are investigated and suggestions made as to their causes.

A MICROSCOPIC EXAMINATION OF IRON-TIN REACTION PRODUCTS.

By W. D. JONES, B.Eng., Ph.D. and W. E. HOARE, B.Sc.

This research, which also forms part of a programme carried out by the International Tin Research and Development Council, was undertaken for the purpose of: (*a*) Giving a fundamental background to an investigation, dealing with tinplate: (*b*) Augumenting the evidence advanced by Edwards and Preece[2] for the compound Fe Su: and (*c*) Comparing the validity of the two recent phase diagrams. As a result of this investigation the existence of three intermetallic compounds in the iron-tin system has been confirmed. These are considered to be of compositions indicated approximately by the formulæ, Fe_2 Su, Fe Sn, Fe Su_2. The existence of the compound Fe Su is supported by evidence additional to that advance by the work of Edwards and Preece. The γ phase of Ehret and Westgren[3] has not been confirmed. The authors state that since all three compounds grow readily from melts at the iron-tin interface, it is reasonable to assume that they permit of diffusion and should therefore be represented on the diagram not as vertical lines, but rather as narrow homogeneity intervals. Until more data becomes available, however, the authors question the wisdom of assigning specific molecular formulæ to the phases discussed.

2 Edwards & Preece: *Jour. Iron and Steel Inst.*, 1931, No. II., p 41.
3 Ehret and Westgren: *Jour. Am. Chem. Soc.*, 1933, Vol. 55, p. 1,339.

THE BEHAVIOUR OF SULPHUR IN OPEN-HEARTH FURNACE GASES.

By E. MAURER AND W. BISCHOF (SCHOOL OF MINES, FREIBERG IN SAXONY.)

In the open hearth process the sources of the sulphur in the steel product are to be found in the materials charged, in the additions both metallic and non-metallic, and in the fuel gas. It is possible by a careful selection of suitable materials to control largely the amount of sulphur introduced into the charge by these or by the additions, but the influence of the sulphur in the furnaces gases is less easily governed. This is the more unfortunate since any actual increase or decrease in the total sulphur can only be effected through the agency of the furnace gases, apart from such transient effects as may be produced by a change in the slag composition by adding lime or fluorspar, or by the skimming off and renewal of the slag covering.

The authors of the present paper succeeded in determining experimentally how the sulphur of the gas, whether in the form of hydrogen sulphide or of sulphide-dioxide, would react with liquid steel containing sulphur.[4] This investigation, however, has not yet been extended to gases of the ordinary composition in practical use, and the results therefore, do not permit of the direct application to the law of equilibrium. In the present paper the authors discuss, in the light of the previous findings, the conditions for the elimination or the absorption of sulphur in the open hearth process, with special reference to the influence of gases of various compositions, and with a view to determining the different behaviours of producer gas, coke-oven gas, and mixed gas.

In the first place the physico-chemical equilibria for the reactions :

$$FeS + H_2 = Fe + H_2S$$
$$\text{and } FeS + O_2 = Fe + SO_2$$

are worked out for liquid steel with a sulphur content above the average, and the distribution of the sulphur between the gas and the liquid steel has been determined for low sulphur contents under the manufacturing conditions for steel in the open-hearth furnace. The method followed was that of mathematical extrapolation, and the dependence of the reaction on the temperature according to Van't Hoff's law is deduced.

An examination of the results obtained in practical working shows that it is the second of the two reactions stated above which governs the distribution of the sulphur.

Secondly, the influence of the composition of the fuel gas, at its passage through the furnace ports, on the desulphurisation is calculated. A comparison of these values with those obtained in practical working has indicated that there was satisfactory agreement with the results of laboratory tests, and an example showing the observed relationship is illustrated buy means of diagrams.

THE MANUFACTURE OF FULL-FINISHED STEEL SHEETS.

By ERIC R. MORT, B.Sc.

In this paper the author gives an account of the methods adopted by sheet-makers in the production of full-finished steel sheets to meet specifications that become increasingly difficult year by year. The rapid growth of the cheaper, mass-produced motor-cars has necessitated development in sheet making practice to cope with an increasing demand for a sheet for the most difficult stampings, having the following characteristics :—

(1) A high surface finish free from blemishes of any description.
(2) A fine, uniform, equi-axed grain structure.
(3) Truth to gauge and size.
(4) Capacity to take the draw for which it is intended.

At first sheet-makers were able to supply a satisfactory sheet by making slight modifications in their practice and taking greater care to prevent surface blemishes. The advent of loose rolling, pickling of "breakdowns" and double box-annealing may be mentioned in this connexion. This state of affairs was not long to continue, however, as improved technique was dictated by the demand for sheets of small, uniform grain structure, sheets in widths never previously rolled, and, in America, by wide-strip mill competition. The latter produced sheets having the requisite grain condition, and made large inroads into the sheet mills' tonnage until the normaliser enabled them to meet this challenge effectively. In order to roll sheets in the greater widths required by body-makers, the three-high sheet mill was adopted, as the two-high jump mill did not perform the work satisfactorily in extreme widths. Finally, mechanisation of the hot-rolling department and the use of four-high cold mills were resorted to so as to bring about a reduction in the cost of manufacture and an increase in the quality of the product, thus meeting the competition of strip mills which were producing full-finished sheets in widths that were being increased almost yearly and at a cost far below the market price.

The author describes the improvements to the basic processes that have been introduced to meet the special conditions imposed by the manufacture of full-finished sheets, and discusses various problems with which the manufacturer is confronted. He concludes that, while there is no doubt regarding the desirability of heavy cold-rolling, a sheet-maker is faced with a number of problems, should he decide to enter this field. First, should the steel be cold-rolled in sheet or strip form? If the former, the problem is a simple one, involving the purchase of one or more four-high mills. If the latter, the problem is not quite so simple, as the choice of equipment is so much wider. The alternatives are, first, a tandem mill ; secondly, a single-stand reversing four-high mill ; and, thirdly, a Steckel mill. It is the author's opinion that the future will see the installation of fewer tandem mills, and that the trend will be towards single-stand mills of either the reversing four-high or the Steckel type.

Since the coming of the wide-strip mill, numerous prophecies have been made that the regular sheet mill would be completely obsolete in America by 1935. This would appear to be somewhat too sweeping a view, but it does seem fairly certain that no more regular sheet mills will be installed in that country—manufacturers will either mechanise existing mills, or adopt the strip method. There are manufacturers who take the product of the wide-strip mill and reduce it still further in two-high or three-high sheet mills, but this may be due to a number of things. They may be forced to this procedure, first, because their strip mill is not designed to roll the wider sheets ; secondly, because the orders are so small and the specification such as to render strip-rolling unprofitable ; thirdly, because of a desire to utilise existing equipment. Sheets are still being made in America on old-time two-high hot and cold mills, but the proportion is becoming smaller every year, as the conservatives are adopting four-high cold mills for use in conjunction with existing two-high or three-high sheet mills.

STRUCTURES AND DENDRITIC SEGREGATION OF STEEL INGOTS.

By L. NORTHCOTT, PH.D., M.Sc., A.I.C.

Studies on steel ingots are described and discussed by the author in two papers presented. One arising out of a routine examination of a number of steel ingots, the structures of two of which were found to be of outstanding interest owing to the peculiar conditions under which the ingots were cast. An examination of these ingots offered an opportunity for the further study of the solidification of steel and some of the results are given. The first part of this paper is devoted to a description of the structures observed in the Parsons-Duncan 20-ton steel ingot. Parson and Duncan[5] described the casting of this ingot. Briefly the process comprises the pouring of the molten

4 F. Bischof: *Dr.-Ing. Dissertation, Freiberg (Saxony)*, 1934.

5 Parsons & Duncan: *Jour. Iron and Steel Inst.*, 1929, No. 1. p. 255.

metal into a mould having its longitudinal dimensions greater than its vertical, thick refractory materials covering the sides of the mould and a bottom metal chill of large dimensions, preheating the mould to a high temperature and continuously supplying heat to the upper surface of the molten metal after casting, so that the upper layer is the last to solidify. Although many of the structures are common to all types of steel ingots, they are developed to an unusual degree in this ingot.

The influence of the casting conditions adopted by Parsons and Duncan, upon the segregation and crystal structure was further investigated; experimental ingots in copper and white cast iron were prepared and studied. In the second part of this paper, the primary crystal structure and its influence upon other structures in the ingot are again considered with particular reference to a bottom-cast ingot made under exceptional conditions of solidification. The ingot examined was one of a group of six 30-cwt. ingots, which had been bottom-cast under conditions of low casting temperature and slow rate of pouring. A peculiar structure was found to exist across the upper part of the ingot, which is discussed.

In the second paper the causes of dendritic segregation in steel ingots is investigated. For this purpose an ingot was required which showed a widely varying degree of coarse dendritic segregation as revealed by the usual methods of etching. These conditions were met by the Parsons-Duncan 20-ton steel ingot to which reference has already been made. Chemical and macroscopical evidence obtained in the examination of a steel ingot showed that the dendritic structure is primarily due to phosphorus segregation. The dendritic structure persisted after decarburisation, but treatment with molten caustic potash reduced the phosphorus content and was the only treatment found to be successful in obliterating the dendritic structure. The dephosphorising action of caustic potash was confirmed by treatment of a phosphoric cast iron and a phosphor-copper in the solid state.

In a third paper the author discusses periodic structures in metals and alloys. A succession of bands or lines has frequently been observed in the macro-examination of steel ingots and castings, running approximately parallel with the surface and lying a short distance below it and the phenomenon has been considered to be due to the ingot shrinking and intermittently settling down in the mould in a series of jerks which occurred whenever the friction at the surface still in contact with the mould became inadequate to carry the ingot. The author has examined the Parsons-Duncan ingot which shows pronounced banding effect, and considers this reasoning does not apply. He considers the banding effect to be due to periodic crystallisation. Similar structures have been prepared in a number of non-ferrous alloys, in which the periodicity was controlled by the casting conditions. A theory, supported by microscopical and chemical evidence, is advanced to explain the structures developed.

THE ELASTICITY, DEFLECTION AND RESILIENCE OF CAST IRON.

By J. G. PEARCE, M.Sc.

In recent years the development of ferritic and austenitic cast irons, as well as the advance in the production of high-duty pearlitic irons, plain and alloyed, has brought about material modifications to the deflection figures, and has necessitated new criteria by which cast iron must be judged. Elasticity, deflection, and resilience are factors involved in physical determinations on cast iron and are discussed in this paper.

The deflection in transverse of grey cast and malleable cast iron comprises two components, elastic deflection and plastic deflection or permanent set. Separation of these components shows that the former is usually a straight line directly proportional to the load and differing relatively little from iron to iron, while the latter increases at a much greater rate than the load and exhibits wide variations in magnitude between different irons. Brittle irons have a low permanent set and tough irons a high permanent set. The elastic deflection increases as the diameter of the bar tested decreases.

In order to offer a more satisfactory basis of comparison between different irons and to avoid difficulties involved in conventional methods of calculation, it is suggested that Young's modulus E be calculated on the elastic deflection of a standard bar at fracture. It is suggested for this purpose that fracture in cast irons be regarded in the same way as the limit of proportionality in steels. The reduction in quantity and size of graphite results in an increased elastic modulus. The elastic modulus, like the transverse rupture stress, increases as the diameter of the bar tested diminishes.

In order to set up suitable criteria for the critical comparison of cast irons, the use is suggested of the elastic resilience, or the work done to the point of fracture based on the breaking load and elastic deflection at fracture, and the energy of rupture, or the work done in breaking the bar based on the breaking load and the total deflection at fracture. The energy of rupture places cast irons satisfactorily in order of toughness.

PRINCIPLES OF THE DESIGN OF BLAST-FURNACE LINES.

By JINDRICH SAREK, ING. DR. MONT. (CZECHO-SLOVAKIA.)

Up to the present blast-furnace design has been largely a matter of experience and intuition. To-day, however, it is claimed that the problem can be solved by adequate metallurgical knowledge combined with the making of measurements, and, in this paper, deals with a new method of designing blast-furnace lines, and discusses the general principles. The underlying principles of the new method are deduced from actual changes undergone by the burden as it descends in the furnace. This method calls for a knowledge of the character of the ores smelted and of the coke used, and requires a temperature diagram to be plotted for the charge worked. Coefficents which are needed for the calculation of individual dimensions of the furnace can be measured or chosen reasonably with a sufficient degree of accuracy. This calculation is related to the burning effect of the furnace, which has been determined by the author from data, given by Evans, concerning the operation of a series of existing furnaces. The effect of the blast-furnaces has been represented in a diagram. It will be seen that the lines of blast-furnaces are very similar to each other. This represents an essential factor in judging the correctness of the method suggested. In conclusion, the dimensions of three particular blast-furnaces are calculated.

PRESENTATION OF BESSEMER MEDAL.

This meeting was of more than usual interest, because his Majesty the King had graciously consented to receive the highest honour of the Institute—the Bessemer gold medal—which is awarded each year for distinction in study and research in metallurgy. The deputation from the Institute who attended the King at Buckingham Palace to make the presentation included the president, Mr. W. R. Lysaght; the senior past-president, Sir Robert Hadfield; the hon. treasurer, Sir Harold Carpenter; and the secretary, Mr. K. Headlam-Morley. It is of interest to note that this was the second occasion for Sir Robert Hadfield to be associated with the presentation of a Bessemer medal at Buckingham Palace; the previous occasion being when he handed the medal to King Edward in 1906.

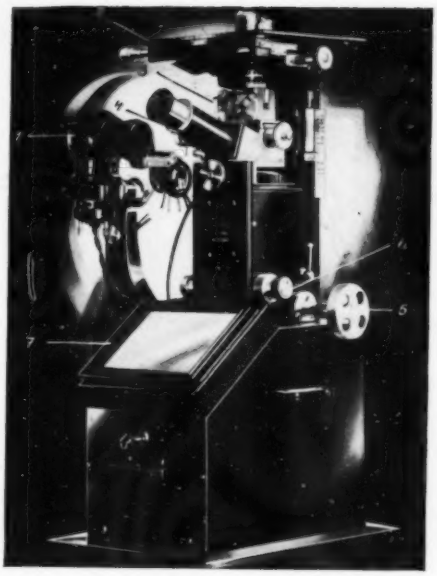


FIG. 1.—*Universal Microscope "Me F," with equipment for reflected light.*

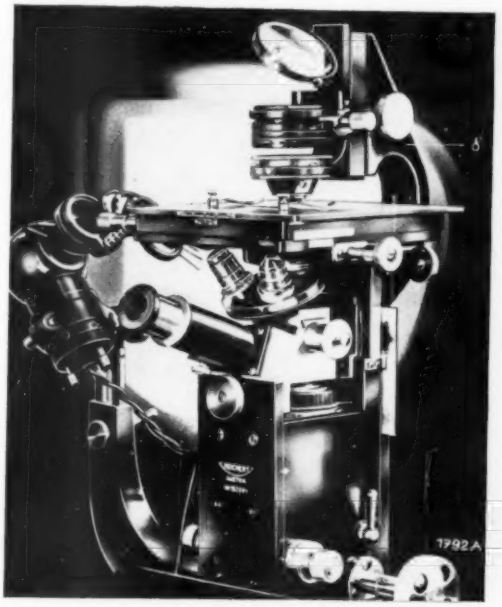
Two New Universal Microscopes.

Whereas the previous trend of microscope design has lain in the development of special instruments to meet the requirements of particular fields of research work, efforts in this direction are now being mainly directed to the creation of universal microscopes designed so as to enable all methods of examination to be utilised in microscope research work on materials.

THE trend in the design of universal microscopes is indicated by two new instruments—a Vertical Microscope "Me F" and a Horizontal Microscope "Me A"* which have been recently developed. These instruments are designed for microscopy and photomicrography in incident and transmitted light (in both cases, using either bright or dark ground illumination), and in polarised light. They also enable photomicrographs or photomacrographs to be taken, as required.

Fig. 1 shows the "Me F" Universal Microscope which, in design, resembles the "dropped microscope" first suggested by LeChatelier. The illuminating equipment (1), comprising the low-voltage 30-watt lamp, collective lens and filters, is arranged to swing out on a vertical axis. The stage (2) may be either a mechanical stage or a round, rotary and centrable stage. The Universal Opaque Illuminator (3) is equipped with Kohler illuminating arrangement (field and aperture iris diaphragms), and arranged so that either of the three types of vertical illumination, described below, can be used at option. The objectives are secured to interchangeable sliders. The opaque illuminator can be easily detached and replaced by the conventional type of revolving objective changer for examinations in transmitted light. The photomicrographic objectives, used for obtaining general survey photographs without an eye-piece, can also be inserted in the path of the rays of the microscope in place of the universal opaque illuminator by removing the latter. The supporting tube for the eyepiece (4) is arranged. obliquely. The rack motion (5) for coarse focussing the object acts on the stage, whereas the fine focussing motion (6) acts on the objective. The camera (7) is built into the base of the instrument and is equipped for plates 9×12 cm. For working with transmitted light, a supplementary arrangement (8), comprising illuminating mirror, condenser and iris diaphragm, is placed on the microscope.

In the "Me A" Model Universal Microscope, the actual stand portion carrying the optical equipment is the "Me F" Microscope, which is, however, modified to suit. The main components of this instrument are arranged on an optical bench of the bridge girder type, which can be suspended free from vibration. A low-voltage incandescent electric lamp (Fig. 2, Part 9), or an arc lamp (10) supplies the illumination. Either of these two light sources can be used as required, depending on the intensity of light needed; the low-voltage lamp for visual work and the arc lamp for photomicrography. The actual instrument or stand (11) differs from the "Me F" Microscope simply by the absence of the camera incorporated in the base, and by the arrangement of a lateral connecting stub for the bellows camera. In the "Me A," the base is used as a support for the bridge type optical bench. Otherwise the equipment of this instrument is the same as the

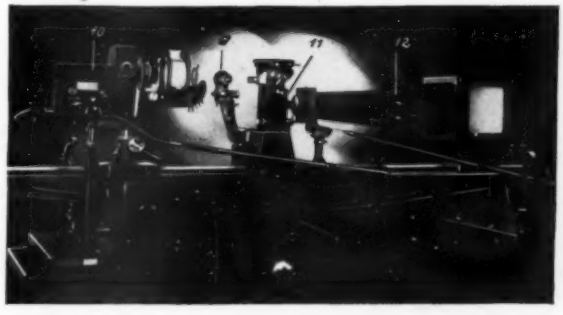


Universal Microscope "Me F," with equipment for transmitted light.

"Me F." The camera (12), for 13 × 18 cm. plates, has an extensible bellows to enable the magnifications of the image to be varied gradually within wide limits.

It should be noted that this instrument can also be

FIG. 2.—*Universal Microscope "Me A," which differs from "Me F" only in possessing camera equipment.*



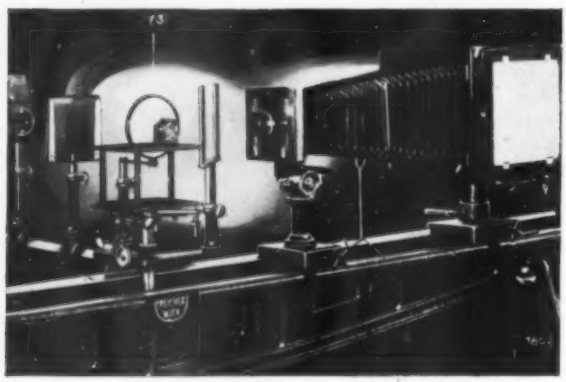
* Manufactured by Messrs. C. Reichert, Optical Works, Vienna.

supplemented by a photomacrographic arrangement (13). This is placed on two supports arranged at the side of the bridge type stand, and, by means of the photomicrographic objectives of between 30 and 100 mm. focal length and a photographic objective (" Neukombinar "), enables general survey photographs to be taken from low magnifications down to reductions, by cutting out the actual microscope. With this equipment, photographs of both horizontal and vertical object surfaces can be taken in incident light with vertical or oblique illumination.

By way of comparison, it should be observed that, although the " Me F " fully justifies the title of an universal microscope, the " Me A " meets further requirements, especially in regard to photomicrography.

We now propose discussing in some detail the methods of working with these Universal Microscopes.

The first microscopic method is the examination of opaque objects. In this incident light method of examination, the object is illuminated and observed from the same side. The objects themselves have surfaces that are partly reflecting, and partly rough and light-diffusing. The light may fall on the object vertically slightly inclined, or quite obliquely. Assuming that the object is totally reflecting, we obtain a bright field of view (bright ground illumination) in the first two cases, since the rays of the light source reach the eye of the observer direct. In the instruments above described, vertical incident illumination is produced by a plane glass plate tilted 45°, in a similar way to the Beck opaque illuminator. The slightly inclined incident illumination is equivalent to Nachet's opaque



Universal Microscope " Me A," supplemented by a photomacrographic arrangement.

illuminator method, except that the total reflecting prism which he uses is replaced by a strip mirror. This enables the numerical aperture of the optical system to be utilised to better effect. Vertical illumination produces images that are slightly less bright, but gives perfect resolution of the object up to the highest-power objectives. The strip mirror gives very bright images, and the slight obliquity of the light brings out the contrasts and the relief effects. On the other hand, the reduced numerical aperture somewhat limits the resolving power of the optical system.

In truly oblique incident illumination what are termed " Epilum " Objectives are used. The " Epilum " is a special objective with an incorporated annular condenser system which gives oblique illumination of the object on all sides or, if a special stop is used, single-sided oblique illumination of the object. The light rays falling on the object are inclined by the condenser so that, with reflecting objects, no light reaches the eye of the observer. With an object of this kind, a perfectly dark field of view (dark ground illumination) would consequently be produced. In the case of objects that are rough and do not reflect completely—representing the normal case—only the diffused light transmitted by the rough portions of the object reaches the eye of the observer. These parts appear bright on a dark ground. Since, with " Epilum " systems, the illuminating rays do not pass through the lenses of the objective, it is impossible for reflexes to be set up at the surfaces of the lenses. Such reflexes would have a very disturbing effect, especially with dark objects. Only by the introduction of these special objectives is satisfactory observation of dark opaque objects possible at all. The highest-powered objective of this type, an oil-immersion system, has an initial power of X 100.

By the suitable introduction of polariser and analyser (two nicol prisms) in the path of the rays, the Universal Microscope can be used for examinations in incident polarised light—a method specially suitable for the examination of unetched metal specimens.

The incident light methods just described were microscopic, *i.e.*, obtained by using an objective and eyepiece. For taking photographs at low magnifications (what are termed " general survey photographs ") the eyepiece can either be dispensed with, or, better still, a special photomicrographic objective (Micro-Polar) is used, which is similar in construction to a standard photographic lens, and is extremely suitable for producing photographs of a fairly large object field. The light required for illuminating the object is either deflected obliquely on to the object by means of a mirror, or projected vertically on to the object by means of a plane glass plate tilted 45°. Both methods of illumination are provided for in the instrument.

Microscopy in transmitted light constitutes the second group of methods of examination. In this case, the light source, the object, and the eye of the observer, are oriented behind each other. Depending on its thickness and structure, the transparent object retains to a greater or lesser extent the light which reaches it and which it modifies by refraction and diffraction. As the light can reach the eye of the observer unimpeded at the places where there is no object, the image of the object appears dark on a bright ground (bright ground illumination).

As in the ordinary microscope, the transmitted light illuminating equipment of the Universal Microscope can be converted for dark-ground transmitted light microscopy by the special reflecting condenser with central stop in conjunction with a suitable funnel stop in the objective. A transmitted light polariser and analyser enable examinations to be made in transmitted polarised light.

For taking general survey photographs in transmitted light, the same photomicrographic objectives are used as for incident light. When working with an objective and eyepiece, visual examination of the image is made through the eyepiece or on the ground-glass screen. When the photomicrographic objectives are used, visual examination is confined to the ground-glass screen. An objective record of the image is obtained on the photographic plate, which can easily be inserted in the instrument in place of the ground-glass screen.

It should be noted that, instead of observing the object with one eye through the eyepiece, examination with both eyes is possible by means of what is termed a " Stereo-attachment," the image obtained being either simply binocular, or stereo-binocular, depending on the optical method used for dividing the rays.

In conclusion, readers should note that both the above instruments are manufactured with the simplest equipments for one of the methods of examination described above, although each instrument can be built up and converted into the universal microscope. As regards the precise equipment of these instruments, particulars are given in the lists and working directions of Messrs. C. Reichert, Optical Works, Vienna, and in a paper by P. Ramsthaler: *Ueber ein neues Universalmikroskop* which has appeared as a reprint from the *Zeitschrift fur wissenschaftliche Mikroskopie und fur mikroskopische Technik*, Vol. 50, 1933, pp. 63–72, published by S. Hirzel, Leipzig.

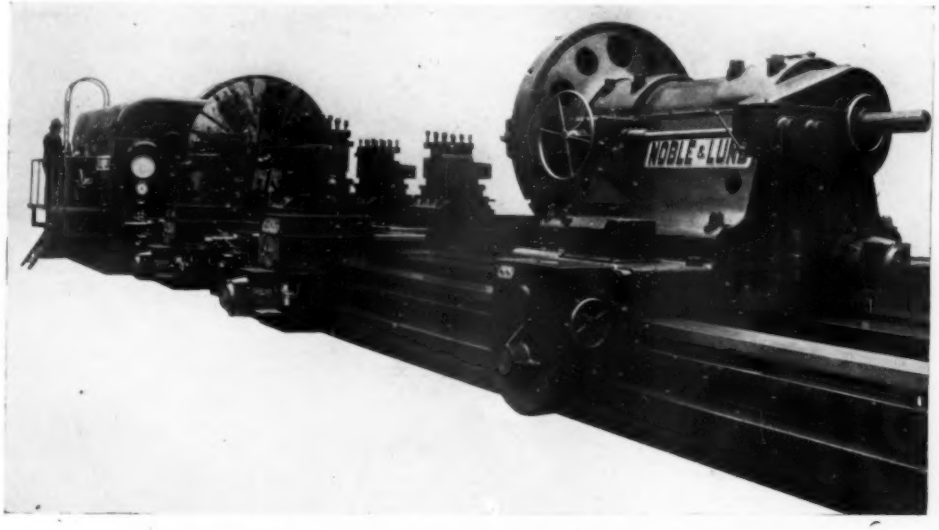
Recent Developments in Tools and Equipment

Powerful Lathe for Boiler Drums.

DURING recent years many factors have been operating against what was recognised as standard practice in machine-tool design. The rapid progress made in the development of high-duty alloys and the need for increased speed of production are two important factors that have necessitated considerable research in order to effect improvements in machine tools to meet the more exacting requirements. In many instances, however, new types of appliances or equipment have been responsible for special types of machine tools. A noteworthy example is the powerful lathe recently installed at the Vickers Works of the English Steel Corporation, Ltd., for coping with large boiler drums which are a feature of modern power plants. by the Corporation at their North Street Works, Openshaw, Manchester, proved the most suitable.

Specially designed and built by Noble and Lund, Ltd., to the order of the English Steel Corporation, Ltd., in order to speed up the machining of large forgings, this lathe embraces many important mechanical and electrical features, and a brief reference to some of them will be of interest.

The main drive to this lathe is by a 250 h.p. variable speed motor direct coupled by flexible coupling to the massive headstock, the latter weighing about 75 tons. The gearing, shafts, and spindle in the headstock are all made from special steel forgings supplied by the English Steel Corporation, Ltd. There are four rates of speed to the main



One of a number of special types of machine tools installed in the centralised machine shops at the Vickers Works of English Steel Corporation, Ltd. It is designed especially for machining large forgings.

This installation is included in a comprehensive scheme of reorganisation of the Vickers Works in order to reduce production costs, part of which embraces the machine shops, which have been entirely rearranged. The work has been concentrated in a central machining section, which has been extended and modified to suit anticipated requirements, while outlying shops have been closed down. As a result of this centralisation the cost of transport of materials has been considerably reduced. In order to cope with the developments in practice, a number of new machine tools have been installed, which include centre lathes up to 92 ft. long by 5 ft. swing; double-ended boring machines for work up to 24 in. diameter by 75 ft. in length; puncher slotting machines up to 4 ft. stroke, etc. The completed machining section, which contains nearly a mile of bays, and houses machines for economically machining the products of the various steel-making departments, is an exceptional example of a modern heavy machine shop. With this central machine shop the English Steel Corporation are in an ideal position for dealing with all the heavy forgings up to 150 tons in weight, castings, etc., for which there is such a demand, and which they are continually manufacturing in their various departments.

Of the new installations none is of greater interest than the powerful lathe erected in the section by Messrs. Noble and Lund, Ltd. During the first run of this machine on a large boiler drum, 45 ft. long, 5 ft. 6 in. diameter, and weighing 88 tons, for the Fulham power station, it removed 3½ tons of material in an hour, working well within its capacity. It is of interest to note that many experiments were carried out with tool steels, and the special steels made spindle by change speed gearing which, in conjunction with the speed variation of the motor, give a range of spindle speeds of approximately ¼ to 30 r.p.m. The keys in the driving shafts are all machined out of the solid forging. All the driving shafts run in roller type bearings, with the exception of the last motion shaft and the main spindle which run in parallel gunmetal bearings.

The lubrication of the headstock has been given very careful attention, and is taken care of by means of a motor-driven oil pump which delivers oils from a large tank, through a filter, to a tank at the top of the headstock. This latter tank delivers the oil to all the bearings and also cascades on to the various gears. The pump motor is started up by means of push buttons on the headstock instrument panel, and these buttons are interlocked with the main motor buttons so that the lathe cannot be started until the pump motor is working. Electric lights are fitted inside the headstock so that the lubrication arrangement can be seen at a glance through the windows provided in the cover.

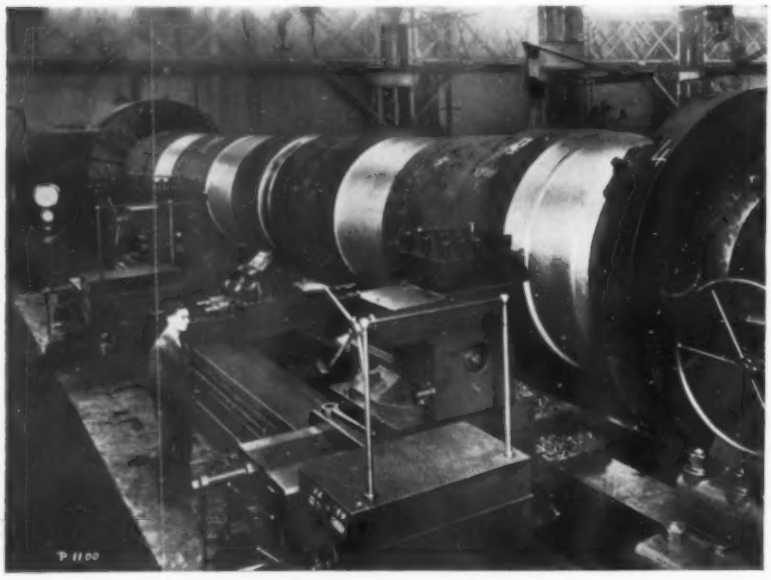
The instrument panel contains tachometer, ammeter, electric lights to indicate that oil pump motor is working, and a full set of push buttons. These push buttons control the oil pump motor and also give full control to the main drive motor in forward or reverse directions.

The central gear for the driving motor is built into the headstock, and the panel containing all the electric contactors, etc., is arranged on hinges to swing out by means of screw gear when access is required to the back connections. Steel hinged doors enclose the panel. The resistances are mounted in a special ventilated compartment attached to

the headstock. The tachometer is of the two-range type, one range being for use on high speeds, and the other on low speeds, the ranges being automatically selected by a switch operated from the gear change mechanism.

The faceplate is a massive steel casting bolted to the spindle and is fitted with eight strong steel gripping dogs. The drive to the faceplate is by means of a large forged steel machine-cut double helical gear ring bolted to the faceplate. This double helical gear is suitably enclosed and receives its lubrication from the cascade system. The double helical pinion is solid with the shaft and is supported by bearings on both sides.

The bed is of the double type and carries two front tool saddles and two back tool saddles. Made in six large sections with longitudinal centre joint and staggered transverse joints, the bed is rigidly keyed and bolted together. The saddles are exceptionally massive and the tool rests are made from steel castings. Narrow guiding arrangement is provided for each saddle along the bed.



A general view of the lathe in operation on a large forging.

The feed motions to the saddles and tool rests are particularly interesting as these are driven by a separate, independent, variable-speed motor on each saddle, thus dispensing with the usual long feed shafts and tumbler bearings. The feeds operate in inches per minute and suitable indicators on the saddles enable the operator to select the rate of feed required. The saddle aprons carry the variable-speed flanged-type motors and all the necessary gearing for feed changes and quick traverses; each apron is fitted with a separate lubrication pump which delivers oil to all the bearings and gears. Push button station on each saddle controls the main drive motor and also the feed motor. The stop button stops all motors so that when the headstock motor is stopped the feed motors also stop. When it is desired to move the saddles or tool rests with the headstock stationary a special "test" button is provided which enables full use of the saddle motor to be obtained so long as this button is depressed in addition to the required saddle motor button.

Copper collector bars carry the current to the saddle motors, and further collector bars give connection between the saddles and the headstock contactor gear. These collector bars are neatly placed on the front and rear sides of the bed, and are adequately protected by strong sheet steel covers over the full length. All trailing cables are eliminated by this feature.

The control gear for the saddle motors is neatly housed in a ventilated box on each saddle, the lid of which forms a platform for the operator to stand upon to get at the tools. The front tool rests are arranged to swivel for bevel cutting, and self-acting feed motion and quick traverse is also provided on these slides, while the top tool rests are designed to take three tools each when advantage of multiple tooling can be taken.

The tailstock is also of very massive design, the base spreading over the four slide ways of the bed and thus giving great stability. The body of the tailstock has a short cross adjustment for maintaining alignment of centres. The spindle is arranged to rotate with the work when required and is fitted with an inner sliding spindle which carries the large centre for centre work. A cast steel faceplate is provided for fixing to the tailstock spindle when required and four steel chuck dogs are also provided for this faceplate. An auxiliary flange-mounted motor provides the quick power traverse motion for the tailstock along the bed.

As the tailstock has to be lifted bodily and placed in between the two sets of back and front saddles when working on a comparatively short forging, it has been considered advisable to dispense with the collector bar feature for this unit, and the electric current is therefore obtained from the nearest front saddle by means of a short length of cab tyre cable and plugs on these saddles. Hand movement to the inner spindle is provided on two gear ratios—one for quick movement of the spindle and the other for final tightening of the centre.

A massive roller steady is provided for supporting heavy forgings in the lathe, and consists of strong cast-iron base-plate resting on the four ways of the bed and carrying two cast steel pedestals for the rollers. These pedestals are adjustable by screws for varying diameter of work. These rollers are of special steel and are fitted up with roller bearings.

The difficulty of getting rid of the cuttings on a lathe of this size is amply provided for by means of a special scrap conveyer, which is fixed in the foundations under the centre of the lathe and carries the scrap to the end of the lathe where the scrap drops into a skip, the latter being easily lifted by the shop crane and emptied as required. This scrap conveyer is driven by a separate auxiliary motor.

The principal dimensions of this lathe will be of interest and are given in the following table:—

Height of centres	55 in.
Admits between centres	60 ft.
Length of bed	86 ft. 8 in.
Width of bed over shears	12 ft.
Depth of bed	2 ft. 6 in.
Swing over saddles	7 ft. 4 in. dia.
Swing over bed	9 ft. 2 in. dia.
Diameter of headstock faceplate	9 ft. 3 in.
Size of headstock spindle—	
Front bearings	27 in. dia. × 36 in. long
Back bearing	20 in. dia. × 30 in. long
Diameter of tailstock faceplate	7 ft. 4 in.
Size of tailstock spindle—	
Front bearing	22 in. dia. × 27 in. long
Back bearing	20 in. dia. × 26 in. long
Diameter of tailstock inner spindle	15 in.
Feeds—	
Sliding	0·02 in. to 14·4 in. per min.
Surfacing	0·01 in. to 7·4 in. per min.
Spindle speeds	0·6 to 29·8 r.p.m.
Quick traverse to saddles	52 in. to 156 in. per min.
Quick traverse to tailstock	90 in. per min.
Approximate weight of lathe complete with electrical equipment, steadies, and chip conveyer	270 tons
H.p. of main drive motor	250 h.p.
Speed of main drive motor	350/1,050 r.p.m.
H.p. of saddle motors	3 h.p.
Speed of saddle motors	400/1,200 r.p.m.
H.p. of tailstock motor	5 h.p.

Some Recent Inventions.

The date given at the end of an abridgment is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, London, W.C. 2, at 1/- each.

Heat-treatment of Light Alloys.

MANY developments in the efficient and economic production, fabrication, and commercial use of easily oxidisable metals, aluminium and magnesium, have taken place in recent years, and particular emphasis has been laid upon the heat-treatment of such metals. There remains, however, variable factors which must be found and controlled before the heat-treatment used in connection with these light metals will be such as to develop to the fullest possible extent the inherent potentialities of these metals and their alloys.

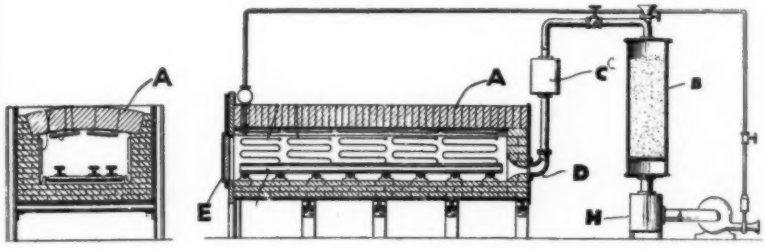


Fig. 1—Plant for heat-treating light alloys in a dry atmosphere.

It is upon the discovery of one of these unperceived factors that a method has been developed, the object of which is to provide a means by which intercrystalline corrosion of the metals or alloys is effectively prevented during heat-treatment. It has been found that the moisture content of the atmosphere in the chamber in which the metal is heated plays a substantial part in the heat-treatment of the light metals and their alloys, and it has also been found that the drying or desiccating of the air which surrounds the metal during thermal treatment produces a definite and beneficial result even, in some instances where the amount of moisture removed from the air is so small as to be apparently inconsequential. In pursuance of this discovery, experiments have been made with the heat-treatment of light metals and their alloys and as a result it has been determined that the deterioration induced in the metals during the heat-treatment by the presence of moisture in the air is cumulative and insidious, and is the explanation, at least in part, for certain defects and inconsistencies heretofore noticed in the light metals and alloys. Moreover, it has been found that the physical properties of the light metals and their alloys may be increased and developed with greater consistency if the moisture in the air surrounding the metals or alloys during heat-treatment be reduced by a preliminary moisture-removing treatment.

As a result of this discovery a plant has been developed which enables the metal to be heat-treated in a dry atmosphere. This plant, shown in Fig. 1, comprises an electrically heated furnace A, to which air is supplied by a fan through a drum B containing a desiccating material such as calcium chloride, activated carbon, silica gel, or, preferably, activated alumina. The air may be preheated in a heater C, and enters the furnace through the pipe D. In operation a current of air is forced through the furnace and after all moist air has been displaced the door E is closed. The pressure in the furnace is then maintained slightly above atmospheric by a valve F in the fan intake, controlled by a pressure actuated device G near the furnace door. The supply arrangements are duplicated so that the material in the drum B can be reactivated at intervals by the heating stove H.

405,111. ALUMINIUM LTD., CANADA, assignees of F. Keller, Jr. Pennsylvania, U.S.A. Feb. 1, 1934.

Adjusting the Gap between Rolls in Rolling Mills.

THE usual method of adjusting rolls to define the magnitude of the effective gap between them is well known. Recently, however, improvements have been effected which have particular relation to blooming mills. In such mills the rolling operation is generally so conducted that the ingot or bloom to be rolled passes successively through a series of grooves arranged side by side. The entire operation is carried out in different rolling periods. In each rolling period the ingot or bloom passes through the same groove several times in succession, the height of the groove, and consequently the effective gap between the rolls, being altered each time. During this operation, however, the roll opening does not diminish continually, because by the placing of the ingot or bloom on edge a greater height of groove, and therefore an increase of roll opening, is required. On the transfer of the ingot or bloom to the next groove in which the second rolling is to take place it is generally placed on edge, and the roll opening must be increased again in accordance with the height of the ingot or bloom on edge, because, owing to the gradual reduction of the groove height at the end of each rolling period, the roll opening becomes practically nil. The main object of the improvements is to effect automatically the adjustment of the roll opening to any magnitude within the range of the mill, both during the reduction and increase of the rol opening.

Fig. 2.

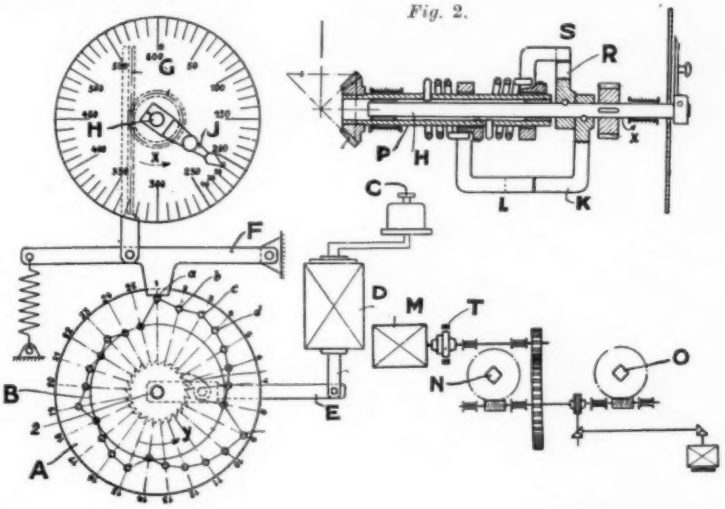


Fig. 1. *Fig. 3.*

The main improvement which gives control of the operation embraces a disc with a pointer, which indicates the roll opening in an easily readable position. This device is positively connected with mechanism which regulates the movement that adjusts the roll opening. In this device by the rotation of the pointer or of the disc in one or the other direction, contact devices are operated that influence the driving motor of the pressure spindles in the one or the other rotational direction.

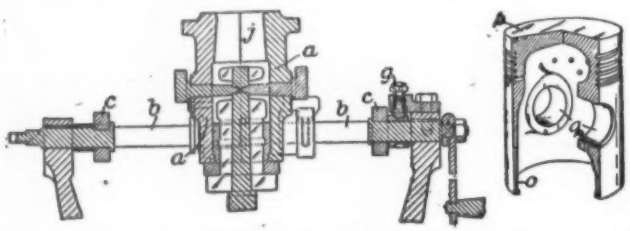
In this way the setting of the pass indicator of a rolling mill is used to operate the pass adjustment motor through

relays for the length of time required to operate the screws to adjust the pass to the particular setting. The control disc A in Fig. 1, is provided with a number of cam pins, *a*, *b*, *c*, *d*, etc., which are set at different radii from a zero circle B to represent pass clearance—for example, 210, 160, etc., millimetres. The disc is rotated one step after each pass by press button C, magnet D and pawl E, to bring, for example, a pin *ba* to lift the lever F, thereby actuating a rack G to rotate a shaft H carrying the pointer J to show the pass setting on a scale. Rotation of the shaft H, Fig. 2, separates relay contact arm K from L, whereby the motor M, Fig. 3, is actuated to turn the pass adjusting spindles N, O. The motor also rotates through gears, the hollow shaft P, Fig. 2, which, after travelling a certain distance, brings the contacts L, K together again and stops the motor M, thus limiting the amount of pass adjustment to the setting indicated. Contacts R and S remain closed until the pass is to be reduced when they open and act similarly to contacts K, L, but driving the motor in the opposite direction for a certain time. The contacts L and S, abut against stop pins and engage tension springs and which allow this delayed action contact closing until the required pass has been set. A brake T prevents overrunning of the motor. Gearing and shaft V couple the shaft P with the motor.

400,899. FRIED. KRUPP GRUSONWERK, Magdeburg-Buckau, Germany. November 2, 1933.

Casting Light Alloy Pistons.

CONSIDERABLE difficulty is experienced in casting pistons in certain alloys of aluminium, such as high silicon alloys, in dies as although the metal flows readily, internal shrinks, porous metal, piping, and cavities occur in the castings. As the usual method of casting is to employ the bottom of the die for casting the crown of the piston and to run the metal into the cored die by means of inclined gates and heads through the body of the die entering the actual



Die mounted on trunnions for casting light alloy pistons.

mould at the sides near the bottom, it follows that the porous metal often occurs in the neighbourhood of the crown, piston ring section, and gudgeon pin bosses, which are drawn upon by other parts of the casting.

To overcome this difficulty, the piston is cast in a die having the pouring gate or header space directly above and in line with the mould; this space being formed of the approximate contents of the body of the piston. The actual mould inside the die is shaped so as to form the bottom part or skirt of the piston at the bottom of the mould in the pouring operation. The finish of the mould proper corresponding to the crown of the piston will be in about the middle of the mould space and only a slight change in diameter is made between this part of the mould and the cylindrical large header space above it. The casting is subsequently parted or cut off from the large coaxial header, and it will be found that all the porous and unsatisfactory metal occurs in the header; the remaining parts of the mould having been well fed, the walls and bosses of the piston casting are in most cases of homogeneous, fault-free, metal.

It is convenient in use to mount the die in trunnion bearings, as shown in the accompanying sketches, so that it can be rotated or, at least, swung through 180°; this permits the core pieces to be fitted and secured readily in the die, and then the die to be turned over for pouring. As the hollow part of the casting, the part within the skirt, is to be below the solid crown in the pouring operation, it is obvious that the fitting of the core pieces would be difficult without turning the die over and the rotatable mounting facilitates the casting operation.

The mould cavity is arranged so that the walls of the skirt *o* diminish gradually from the crown *p* and the molten metal will feed the thin sections downwardly. The die is mounted on trunnions *c*, provided with a spring stop *g* so that it can be inclined for pouring and inverted for insertion of the core, etc. The mould may also be shaped to produce a crown internally arched and gudgeon-pin bosses *q* thicker adjacent the crown to give a good heat flow and strength when the piston is in use.

406,019. BIRMINGHAM ALUMINIUM CASTING (1903) CO., LTD., Smethwick, A. P. FENN and E. COX, also of Smethwick, near Birmingham. February 13, 1934.

Aluminium Alloys containing Cerium.

Aluminium alloys containing 0·5—5% of copper, 0·5—3% of nickel, 0·1—2·5% of magnesium, 0·2—2% of iron, and 0·2—2·5% of silicon, are improved by the addition of up to 1% of cerium. One or more of the metals manganese, chromium, and titanium may be present. The alloys may be aged at not over 300° C., and such ageing may be preceded by quenching from 480—570° C. The alloys may be made by adding to molten aluminium a number of aluminium alloys each containing one or more of the constituent elements, the magnesium being added last as such; or the cerium may be added as metal or as an alloy with any of the other metals. A mixture of cerium oxide 10—20%, barium nitrate 30—40% and sodium chloride 40—60% is employed, one to two kilograms being added to each ton of fuel. The mixture may be distributed in the fuel in the form of powder or of an aqueous solution or suspension.

403,700. J. Stone and Co., Ltd., Deptford, London, A. J. Murphy, Cambridge Road, and S. A. E. Wells, Atbara Road, both of Teddington, Middlesex.

Welding Rods.

Arc welding electrodes or welding rods provided with a coating containing cellulose are submitted to a heat treatment to effect a partial decomposition of the cellulose, while leaving a residue capable of producing a protective atmosphere in the arc. A large proportion of the gases evolved thereby are thus removed while retaining the cellulose in a cohesive non-friable form. The coating may consist of a winding of cotton impregnated with solutions or emulsions of metallic salts, clay, etc., or a helically applied mixed cotton and blue asbestos yarn, or a braided yarn of mixed cotton and blue asbestos fibres. The core may also be coated first with cotton or other cellulose material and then with a slag forming material such as a mixed yarn of blue asbestos and cotton. The electrode is first heated to about 120° C. to expel moisture from the coating and is then heated to not less than 250° C. or more than 320° C. to effect the partial carbonization of the cellulose. This may be effected in an oven in the absence of external air, the removal of the products of distillation being assisted by a fan. The electrodes may pass on a conveyer through an oven, the first part of which has a low temperature and the succeeding parts a higher temperature. When mixed cotton and asbestos fibres are used the treatment is effected in an inert or reducing atmosphere to prevent oxidation of the asbestos. The cotton fibres may constitute about one third of the weight of such yarn. The total loss of weight after heat treatment may amount to 50% of the cellulose in the covering. With such an electrode a core containing 1·5% of manganese yields a deposited metal containing 0.5% of manganese.

404,122. Quasi-Arc Co., Ltd., and A. P. Strohmenger, 15, Grosvenor Gardens, London.

Business Notes and News

Tin Buffer Pool Scheme.

At a meeting of the International Tin Committee, recently held in London, the four Governments signatory to the tin restriction scheme (Malaya, Dutch East Indies, Nigeria and Bolivia) agreed to the formation of a buffer stock of 8,282 tons. The possibilities of buffer stock has been discussed some time, the object being to control short-term violent fluctuations in price. In order to supply this pool a special quota of 5 % of the standard tonnages has been sanctioned as from June 1 of this year, and the entire stock must be accumulated before the end of 1934.

New Soviet Testing Machine.

A new type of machine for testing the strength, elasticity, density, and expansion of metal has recently been designed and constructed by the Central Scientific Research Institute for Machine Construction. The new machine is able to test metal under a pressure of 35 tons. Testing machines previously built in the Union were only able to test metals under a pressure of not more than five tons. The machine has three transverses ; the centre transverse is tightly fastened to the bed of the machine, while the upper and lower transverses are operated by an electric motor. While the specimen is in process of being tested, the result of the test is automatically recorded. By this invention, it is claimed, the Union will be able to dispense with the importation of machines of this type.

Ford Blast Furnace in Operation.

Another link in the chain of plants at Dagenham has been connected by the starting up of the blast-furnace. In the completion of this new furnace the ideal aimed at by those who are responsible for the undertaking is almost realised. It was their aim to feed their great factory with raw materials and produce from them the finished motor-cars. Iron ore and coke and limestone at the rate of hundreds of tons a day will eventually be swallowed by the new furnace to produce pig iron for the Ford foundry. Even coke-ovens have been installed to ensure the correct grade of coke for use in the furnace. With typical ingenuity the Company will use gases from the blast-furnace in the manufacturing plant and between two or three million cubic feet of gas will be utilised in this way. The new furnace is the first to be erected in the South of England, and when working at full capacity will produce 500 tons of pig iron every 24 hours.

New Engineers' Tools Department.

A new engineers' tools department at Messrs. Thos. Firth, and John Brown, Ltd., has just recently been officially opened by the Lord Mayor of Sheffield. It is claimed that it constitutes the most modern works of its kind in this country. The new department is in Carlisle Street, East Sheffield. The works are entirely new and are fully equipped for operating on a high efficiency basis. The premises are all on the ground level and the layout is in keeping with the modern conception of advanced methods of manufacture, power transmission, lighting and interdepartmental progress work. The latest principles of roof lighting, ventilation, and air conditioning have been adopted.

The department will concentrate on the manufacture of high-speed steel twist drills, milling cutters, reamers, segmental metal-cutting saws, hack-saws, and high-speed steel lathe tools. Appropriately enough, its completion coincides with the time when there is a definite lifting of the depression from local industry ; it is interesting to know, however, that the preparations for such progress as is now accomplished were begun during the period when tradgng conditions were comparatively slack.

Tungsten Industry in 1933.

The tungsten mining industry made a substantial recovery in 1933, when 895 short tons of concentrated tungsten ore (reduced to an equivalent of 60% WO_3) produced in the United States, were sold, compared with 396 short tons in 1932. The average value per unit of the tungsten concentrates sold increased from $9.20 in 1932 to $9.58 in 1933. Shipments of tungsten concentrates were made from Arizona, California, Colorado, Nevada, and Washington, in quantities ranging from 43 short tons in Arizona to 550 short tons in Nevada.

Galloway Hydro-Electric Scheme.

The English Electric Co., Ltd., has secured a contract for the hydraulic generating plant for the three power stations comprising the second stage of the Galloway Hydro-Electric Scheme. The contract comprises two vertical reaction water turbines and generators, each with a normal output of 14,800-h.p., for the Kendoon Power Station, and four similar sets, each with a normal output of 8,500-h.p., two of which will be installed in Earlstoun Power Station and two in Carsfad Power Station. Both the latter stations will be arranged so that they can be operated by supervisory control from Glenlee.

This contract, which is stated to represent a total value of over £200,000, follows upon those for the equipment for Tongland and Glenlee power stations now being executed by the same firm. When completed the scheme will represent a total normal output of 102,000 k.w., which will be absorbed by the Grid. The alternators, it is understood, will be manufactured at the Stafford works, and the turbines at the Rugby works of the E.E.C.

Tees-side Trade Improving.

While it is generally recognised that the Tees-side area was severely affected by the long depression, it is gratifying that recovery is now being felt. Improved conditions are being experienced in the iron trade in which the number of blast furnaces operating at the end of the first quarter in 1933 was 18, whereas, at the end of the first quarter this year, the number had increased to 28. Production of pig-iron increased from 85,000 tons to 146,700 respectively in these quarters, while steel production has increased from 105,500 tons to 169,800 tons.

Even in shipbuilding there is slight improvement but the most gratifying feature is the enterprise which firms in this area are showing in the development of new products. New steels are being produced which are being used in enormous quantities in such industries as the manufacture of motor vehicles and aircraft. Insufficient is yet known of these developments, but it is likely that many of the finishing trades will erect plants in this area. It is of course easy to advocate the facilities in this area for new industries, but it is not so easy to suggest what kind of industries should be attracted. It is probable however that the tin plate trade, weldless tube manufacture, and the non-ferrous metal trades would be found most suitable to make the most of the peculiar advantages which the district possessed.

Future of the Gas Industry.

The future of gas in the home, as a scientifically-controlled fuel for industrial processes, and as a motive power for transport, were subjects discussed recently at the Yorkshire District conference of the British Commercial Gas Association, at Harrogate.

A promising outlook for the future was claimed both for their industry and the country generally by Mr. Francis Barber, president of the conference, and chairman of the Harrogate Gas Company. Speaking of the advantages of gas as a method of lighting and heating, he suggested, on the authority of Mr. Pridgin Teale, a former Leeds surgeon, that whereas gas was the nearest approach to natural light, electricity was very damaging to the eyes.

Mr. C. S. Shapley, manager of the Leeds gas undertaking, claimed that a new stove recently produced would revolutionise smoke abatement in the cities, while Sir John Eaglesome, chairman of the British Gas Light Co., looked forward to seeing compressed gas cylinders with a special low rate of vehicle tax. He suggested that gas, when off the peak period, be used for bulk supply to industry to help the producer, and at a price which would make such a move attractive to the consumer also.

New Coke Ovens.

The Grassmoor Company, Ltd., of which Major I. W. Lamonby is chairman and managing director, has installed a coke oven plant, and the first oven has now been initially charged.

Last July 60 of the old ovens were dismantled and a contract placed for the erection of a battery of under-jet regeneration ovens, from which the output of coke will be about 2,000 tons per week. The Grassmoor Co. supplies gas to Chesterfield Corporation, and the surplus gas for sale to gas undertakings will amount to between three and four million cubic feet per day.

Gold Mining in Wales.

It is noteworthy that the Prince Edward Gold Mines at Trawafynydd has been taken over by a Lonnon syndicate at a cost of £20,000 and the County Council has been approached with a view to improving roads to the mines. Instructions have been given for the improvements to be put in hand and the syndicate purpose linking mine roads with those constructed by the Council.

Rich gold veins have been discovered at these mines, and it is understood that the new company purpose installing modern machinery and introducing electric power. At present the miners are working underground by the aid of candles, but with the improvements contemplated it is expected that more miners will be employed.

New Cupola Started.

A new cupola, built to the specifications of the British Cast Iron Research Association, has recently been installed in the Caledonian Foundry of Messrs. F. Parramore and Sons (1924) Ltd., Sheffield. This cupola incorporates advances in cupola practice and is claimed to be the most economical and best improved type of cupola for melting iron.

Cardiff-Dowlais Steel Works Development.

The Government Order announcing the continuance of the import duties on iron and steel without making any limit to the period has created a feeling of optimism throughout the iron and steel industry. One of the results of this announcement concern the proposed new works of the British (Guest, Keen, Baldwins) Iron and Steel Co., Ltd., which was dependent upon this order, and on which a decision has now been made to proceed. The developments at its Cardiff-Dowlais steel works will cost about £2,000,000, and the work will occupy nearly two years.

In these new works it is planned to manufacture 300,000 tons of billets and sheet bars per anntum. Work will be provided for 1,500 men, in addition to increased numbers indirectly at the mines, the docks, the railways, the limestone quarries, the iron-ore mines and the generating station.

Rolled Zinc in 1933.

The output of rolled zinc (sheet zinc, boiler plate and strip zinc) in the United States in 1933, according to information fornished by the United States Bureau of Mines, was 41,261 tons, valued at $6,055,000, compared with 39,731 tons, valued at $5,029,000, in 1932. Thus, the production was 4% higher and the value 20% higher in 1933 than in 1932. In addition to the quantities given, scrap originating in fabricating plants operated in conjunction with zinc-rolling mills was rerolled and production therefrom amounted to 6,342 tons in 1933, and 8,066 tons in 1932.

Zinc used in rolling was made up of the following grades: Brass special, 56%; prime western, 16%; high-grade spelter, 15%; intermediate, 10%; and electrolytic, 3%. In 1932 the grades used were reported as follows: Brass special, 55%; prime western, 18%; high-grade spelter, 14%; electrolytic, 10%; and intermediate, 3%.

Electric Furnace Company.

The report of the directors of this progressive Company, for the year ending March 31, 1934, emphasises improved conditions of business, especially at home, the total value of orders received being the largest in the Company's history. The melting net profit for the year is £20,574, and a very important factor in this success was the increased use of high frequency furnaces for melting steel. Several new steel melting shops in the Sheffield district have recently been equipped with high frequency melting units, and have caused a great deal of interest throughout the world, as this country is recognized as being in advance of others in this valuable improvement in steelmaking practice.

It is noteworthy that orders for furnaces have been received from Northern Rhodesia, the Transvaal, Sweden, France and Belgium, while the percentage of orders for this country had increased substantially. The general improvement in the metal trades has gained momentum in Great Britain, but in Continental countries, other than Scandinavia and Belgium, orders have been scarce. The policy of co-operation with important British and Continental firms which this company adopted has proved to be of great value and is being extended. It is gratifying that the salaries of the Staff, which were reduced in 1931, have now all been restored to the former level.

Wellman Smith Owen Engineering Company.

Although the results of the past year's trading of the above Company has resulted in a loss, Sir Samuel Roberts, Bart. (the chairman), at the recent annual meeting, thinks it should not be stressed unduly, because in the latter half of the year under review and this year up to this date the Company has secured several contracts of considerable value. The volume of work in our workshops at Darlaston may be said now to be quite satisfactory. These works are well equipped and maintained in a state of efficiency and can deal with a very large amount of orders; whilst, therefore, there is no congestion and we are still able to give first rate delivery at economical prices, the Company is very much happier than it was 12 months ago in respect of works' turnover.

Commenting on recent developments in the iron and steel industry, Sir Samuel said, "As you are aware, there has been a great deal of discussion and activity with regard to the reorganisation of the Iron and Steel industry. This reorganisation can take two forms, firstly internal reorganisation, by which individual firms erect new plant and machinery, either in their existing works or in entirely new works so as to bring their methods of production up to date, reduce their costs and enable them to face any competition they may meet—there are several outstanding instances at the present time of this kind of effort; secondly, reorganisation of the industry as a whole through various Trade Associations.

Park Gate Iron & Steel Company New Rolling Mill.

The report and balance sheet, which showed a disposable balance of £54,404, of the above Company was adopted at the recent annual meeting. In discussing the trade of the year, Mr. Douglas Vickers, chairman of directors, stated that one of the striking things was the recovery about August. The first six months or so of the year were carried on on the same level as the previous year. Then with autumn came a revival of trade due largely to greater confidence and possibly also to some extent to the exhaustion of the stocks held by people who had laid in foreign material in past times.

The output of the works for the last six months was very much in excess of that of the first half of the year. Taking the capacity of the Park Gate last year at about 200,000 tons of ingots, in the first half of the year the works ran at about 70% capacity, whereas in the latter half the percentage rose to 94. The larger output and the spreading of general charges over it had brought about the very much improved results.

Mr. Vickers went on to explain the circumstances leading up to the Board's decision to instal a new 12-in. rolling mill, and said this new department would be of the most modern type, well equipped and capable for handling all the works necessary. The mill was likely to cost when complete £50,000. and the Board thought it would very well take its place in the ordinary earning capacity of the company.

Ruston & Hornsby.

Economies in operating costs rather than increased business has probably helped this Lincoln firm of agricultural and general engineers to improve its trading result. In the year ended March 31, 1933, a loss of £49,604 was recorded, against one of £92,356 for the previous year; for 1930–31 there had been a loss of £34,703. For the year just ended, however, operations resulted in a trading profit of £53,224, which is the best result recorded since the trading profit of £98,639 for 1929–30. To the trading profit is added £18,600 representing a dividend received from Ruston-Bucyrus, Limited—the associated company in which it holds a joint interest with a Canadian company and which specialises in excavating machinery—while directors' fees took £1,439, and debenture interest required £25,050, leaving a total profit of £45,335, against a net loss of £76,123 for the previous year, and reducing the debit balance at profit and loss account to £74,130. Buildings, plant, etc., have been maintained out of revenue, but it has again been considered advisable to place the annual charge for depreciation against capital reserve account. The directors explain the gratifying continuance of the improvement by reporting a considerable expansion in sales. The volume of business, however, at present market prices, is still insufficient to produce satisfactory profits, but it is hoped that the improvement in trade will continue and the directors consider that, on the whole, the outlook is more encouraging than it has been for some years.

ASSOCIATED BRITISH MACHINE TOOL MAKERS LTD.

17, GROSVENOR GARDENS. LONDON, S.W.1.

A B M T M TOOLS COVER THE MANUFACTURING WORLD

The A B M T M group of machine-tool makers covers the whole field of machine-tool building, giving the engineer at home and abroad a unique manufacturing and sales service.

Apart from the main specialities of the Associated firms, as given below, customers have the advantages of the pooled research, the accumulated experience and the entire technical resources of the whole group.

The abundant advantages thus provided by group co-operation will be obvious. The after-sales service provided is of a kind beyond the scope of the single manufacturer.

THE MAIN SPECIALITIES of the Associated Firms are as follows:

Drilling Machines.	James Archdale & Co., Ltd. Birmingham. Wm. Asquith, Ltd., Halifax.
Lathes.	John Lang & Sons, Ltd., Johnstone, Glasgow.
Boring Machines and Boring Mills.	Wm. Asquith, Ltd., Halifax. George Richards & Co., Ltd., Manchester.
Gear Cutting Machines.	J. Parkinson & Son, Shipley, Yorks.
Grinding Machines.	The Churchill Machine Tool Co., Ltd., Manchester.
Turret & Capstan Lathes.	H. W. Ward & Co., Ltd., Birmingham.
Planers, Slotters, etc.	The Butler Machine Tool Co., Ltd., Halifax.
Plano Millers Screwing Machines	Kendall & Gent (1920), Ltd., Manchester.
Milling Machines.	J. Parkinson & Son, Shipley, Yorks. Jas. Archdale & Co., Ltd., Birmingham.
Wheel Lathes.	Wm. Asquith, Ltd., Halifax.

For further particulars write to:

17, GROSVENOR GARDENS, LONDON — S.W. 1.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£100	0	0			

ANTIMONY.

English	£42	0	0	to £43	0	0
Chinese	33	0	0	to 34	0	0
Crude	24	10	0			

BRASS.

Solid Drawn Tubes	lb.	9d.
Brazed Tubes	„	11d.
Rods Drawn	„	8¾d.
Wire	„	7¾d.
*Extruded Brass Bars	„	4¼d.

COPPER.

Standard Cash	£33	0	0
Electrolytic	36	0	0
Best Selected	35	5	0
Tough	34	15	0
Sheets	62	0	0
Wire Bars	36	0	0
Ingot Bars	36	0	0
Solid Drawn Tubes	lb.	10d.	
Brazed Tubes	„	10d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	3	6
‡Ferro Tungsten	„	0	3	3
NOMINAL — Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
2–4% Carbon, scale 11/- per unit	ton	31	0	0
4–6% Carbon, scale 7/- per unit	„	23	0	0
6–8% Carbon, scale 7/- per unit	„	22	10	0
8–10% Carbon, scale 7/- per unit	„	22	10	0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	34	5	0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36	10	0
§Guar. max. 0·7% Carbon, scale 15/- per unit	„	39	2	6
‡Manganese Metal 97–98% Mn.	lb.	0	1	4
‡Metallic Chromium	„	0	2	5
§ Ferro-Vanadium 25–50%	„	0	12	8
§ Spiegel, 18–20%	ton	7	10	0
Ferro Silicon—				
Basis 10%, scale 3/- per unit	ton	6	5	0
20/30% basis 25%, scale 3/6 per unit	„	8	2	6
45/50% basis 45%, scale 5/- per unit	„	11	17	6
70/80% basis 75%, scale 7/- per unit	„	18	10	0
90/95% basis 90%, scale 10/- per unit	„	28	17	6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	13	15	0
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20–25%	ton	15	18	0
§ Ferro-Molybdenum, Molyte	lb.	0	5	6
§ Calcium Molybdate	„	0	5	4

FUELS.

Foundry Coke—						
S. Wales	1	5	0	to 1	7	6
Scotland	—			1	8	0
Durham	1	1	0	to 1	5	0
Furnace Coke—						
Scotland	—			1	5	0
S. Wales	0	19	0	to 1	0	0
Durham	—			0	17	6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£54	15	0
*Commercial Ingots	42	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0	9
*Cored Bars	„	0	0	11

LEAD.

Soft Foreign	£11	4	0
English	12	15	0

MANUFACTURED IRON.

Scotland—			
Crown Bars, Best	£10	5	0
N.E. Coast—			
Rivets	10	15	0
Best Bars	10	5	0
Common Bars	9	5	0
Lancashire—			
Crown Bars	9	0	0
Hoops £10 10 0 to	12	0	0
Midlands—			
Crown Bars	9	12	6
Marked Bars	12	0	0
Unmarked Bars from	7	5	0
Nut and Bolt Bars £6 15 0 to	7	10	0
Gas Strip	10	12	6
S. Yorks—			
Best Bars	10	15	0
Hoops £10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	10½d.
†Sheet to 10 W.G.	„	11d.
†Wire	„	12d.
†Rods	„	11d.
†Tubes	„	1/4
†Castings	„	1/1½

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	11	0
Foundry No. 1	3	12	6
„ No. 3	3	10	0
N.E. Coast—			
Hematite No. 1	3	8	0
Foundry No. 1	3	10	0
„ No. 3	3	7	6
„ No. 4	3	6	6
Silicon Iron	3	10	0
Forge	3	6	6
Midlands—			
N. Staffs Forge No. 4	3	7	0
„ Foundry No. 3	3	11	0
Northants—			
Foundry No. 1	3	10	6
Forge No. 4	3	2	6
Foundry No. 3	3	7	6
Derbyshire Forge	3	6	0
„ Foundry No. 1	3	14	0
„ Foundry No. 3	3	11	0
West Coast Hematite	3	7	0
East „ „	3	8	0

SWEDISH CHARCOAL IRON AND STEEL.

Kr. per English ton @ 19·40 to £1 approximately.

Pig Iron Kr. 98
Billets Kr. 240-290 £13 10 0–£16 0 0
Wire Rods Kr. 280-320 £15 15 0–£17 12 6
Rolled Bars (dead soft) Kr. 190-210 £10 12 6–£11 11 0
Rolled Charcoal Iron Bars Kr. 290 16 0 0
All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£26	0	0
„ Brazery	23	0	0
„ Wire	—		
Brass	19	10	0
Gun Metal	25	0	0
Zinc	9	10	0
Aluminium Cuttings	69	0	0
Lead	10	0	0
Heavy Steel—			
S. Wales	2	14	0
Scotland	2	10	0
Cleveland	2	10	0
Cast Iron—			
Midlands	2	7	6
S. Wales	2	7	0
Cleveland	2	12	0
Steel Turnings—			
Cleveland	1	17	6
Midlands	1	13	0
Cast Iron Borings—			
Cleveland	1	7	6
Scotland	2	0	0

SPELTER.

G.O.B. Official	—		
Hard	£12	2	6
English	15	10	0
India	14	5	0
Re-melted	14	17	6

STEEL.

Ship, Bridge, and Tank Plates Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	9	0	0
„ „ (Marine) „	—		
„ „ (Land), N.E. Coast	10	0	0
„ „ (Marine) „	10	10	0
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	0	0
Light Rails £8 10 0 to	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £8 2 6 and	8	12	6
Medium Basic £6 12 6 and	7	2	6
Soft Basic	6	0	0
Hoops £9 10 0 to	9	15	0
Manchester Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	5	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ½ in. to ¼ in.	„	3d.
Under ¼ in. to $\frac{1}{16}$ in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ⅛ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/-

TIN.

Standard Cash	£232	0	0
English	232	10	0
Australian	—		
Eastern	230	0	0
Tin Plates I.C. 20 × 14 box	0	17	3

ZINC.

English Sheets	£23	10	0
Rods	28	15	0
Battery Plates	—		
Boiler Plates	—		

* McKechnie Brothers, Ltd., quoted June 14. † C. Clifford & Son, Ltd., quoted June 14. ‡ Murex Limited, quoted June 14.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

Prices quoted June 14, ex warehouse.